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PRODUKTOGRAPH center for industrial data gathering

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Control of Production Runs by PRODUKTOGRAPH Systems

By Leonhard Fuchs

The progressive automation of production necessitates extensive rationalization in general operations control. A great deal of such work is still concerned with data gathering. As there is frequently no personnel available for data gathering alone, scheduling has to be based on a few sets of data determined more or less by rule of thumb. But even where personnel is available, the data selected from the mass of registered statistics are liable to be influenced by subjective judgments and may therefore easily lead the management to wrong conclusions. The optimum solution to such problems is obtained by providing facilities with which data gathered directly at machines can be communicated automatically to a central point for indication, registration and graphic recording. Recourse may here be taken to PRODUKTOGRAPH* systems, which are specially designed for modern production scheduling, production control, data gathering and costing. They can be so arranged that the results obtained are fed directly to a data-processing system. The colored illustration on the opposite page shows the example of a PRODUKTOGRAPH center, the function and operating principle of which will now be described.

* Trade-mark

Transmitters

The starting point for the automatic gathering of interdepartmental data is the manned positions and machines, where it is gathered during the actual flow of production. The hitherto conventional entry of output, time, performance and machine state data on sheets is in this way rendered superfluous. Automatic and semi-automatic transmitters communicate data gathered on the spot directly to the PRODUKTOGRAPH center. The variety of machines used in different branches of industry, their manifold different functions, and problems of subsequent data evaluation call for transmitters and combinations of transmitters that depend for their operation on a wide range of principles drawn from the field of physics. It should here be stressed that efficient data gathering at the PRODUKTOGRAPH center depends on the expert designing of the transmitter assigned to each machine.

The running time of a machine can be determined with the aid of unassigned contacts of the on-off relay. In the case of punching machines and presses, position switches that respond to the motions of certain machine parts are commonly used for output counting. Current and active power relays indicate machine downtimes and load

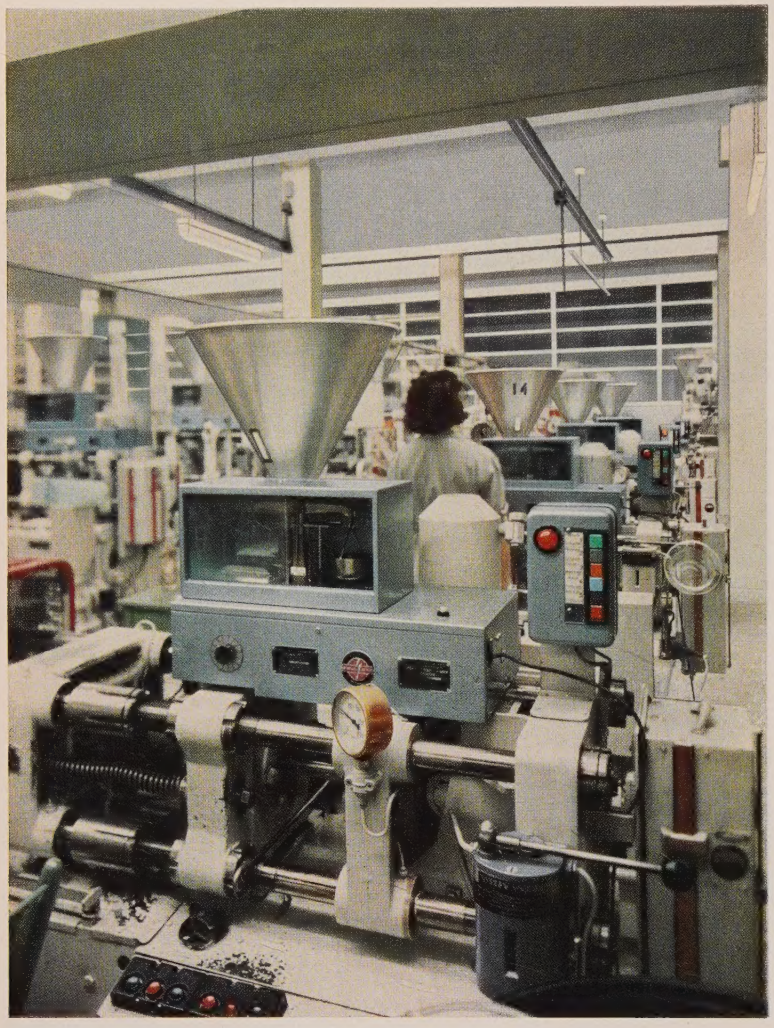

Fig. 1 Data gathering in a plant that produces plastics

periods. Workpieces in machines and on conveyor belts, as also the motions of the machines, can also be determined by photocells. Microphones for solid-borne sound which are assigned to drilling and milling machines operate to sound pressures above a certain level and also permit quantitative output counts for multiple tools. Linear unit transmitters are used in the textile industry, the cable industry, in rolling mills, and in wire factories. In the bottling industry, bottle counters count the output of bottles. Special designs may be necessary in exceptional cases.

The information capacity of automatic transmitters is increased by semi-automatic devices termed interruption switches (Figs. 1 and 2). The reason for the stopping of a machine or for any other interruption of work can be communicated to the system by pressing a button. The causes of interruptions can be designated arbitrarily according to the type of plant. It is advisable for such terms to be standardized and classified under headings such as "No Order", "Machine Repair", "Tool Damage", "No Material", "Loading/Unloading".

The registration of downtimes according to their causes is particularly important for the appraisal of cost fluctuations. If the cause of an interruption has not been communicated to the center by pushbutton, the machine attendant is reminded to do so by a red light. Provision is made for downtimes necessitated by production processes by dimensioning the electronic delay relays so that such interruptions are not indicated. When work is resumed following an interruption, the first output pulse magnetically triggers the interruption switch and the counting of output and productive operating time is resumed.

Further information is very often required for costing and data processing. The indication and transmission of the serial number of the order that is being processed or of similar numbers is accomplished with the aid of number-transmitting-equipment installed at the plant.

Another means of communicating certain classes of data to the center is the press-to-talk/two-way intercommunicator, which is likewise installed at the plant. Announcements can here be recorded on magnetic tape. The intercommunicator can be used to communicate decisions from the center to the plant.

Indications at center

The data and states gathered at the machines and manned positions during production are indicated, registered and graphically recorded with the aid of central devices (colored illustration opposite page 285 and Fig. 3). Luminous signals draw attention to special conditions.

Graphic recorders (Fig. 4) at the center operate with a paper feed rate of 30 mm/hr, each recording the data received from 20 respective machines. Each machine is assigned two recording lines, one of which is for output or production time, while the other is for the duration and type of interruptions. Output quantities can be printed in tens, hundreds and thousands along the second line. Analysis of the plot permits conclusions with regard to, say, the state of wear of the machine and is useful when making decisions on capital investments. Individual analyses can be made with the aid of a high-speed recorder with a paper feed rate of 1,800 mm/hr. Machines can be selected for this purpose with a selec-

Fig. 2 Data gathering in a lathe workshop; the interruption switches are to be seen on the right-hand side of each lathe

tor switch. The results are used both for quality control and quantitative output appraisals.

The counters installed at the center furnish readings on output, machine running times and machine downtimes. Supplementary devices can be used to call for registered data, which may be stored in tape or punched cards. These devices represent links leading to the data processing systems.

The data covering a group of machines or an entire department are registered by summing devices which indicate both the overall production time consumed and the proportional time consumed by the various interruptions. The intercomparison of such data over long periods makes it possible to judge the utilization of productive capacity of the respective unit.

The extent to which individual orders have reached completion is indicated by linear counters, which are assigned to the individual machines (Fig. 5). Linear counters indicate the nominal output required by the order, which is indicated by an adjustable yellow tape, while a blue tape is advanced in correspondence with the rate of output. The scale of this device can be set in tens, hundreds

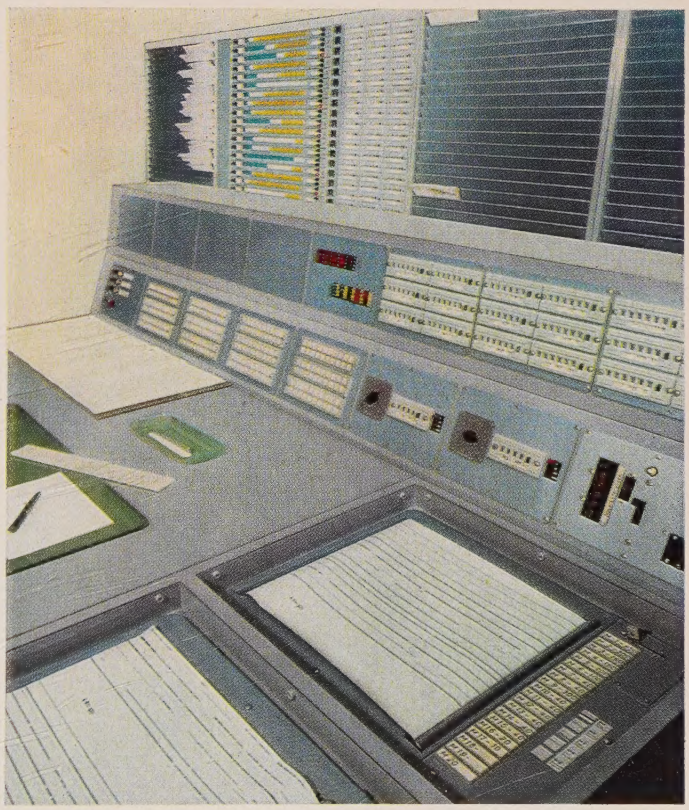

Fig. 3 Section of Produktograph center showing the control console

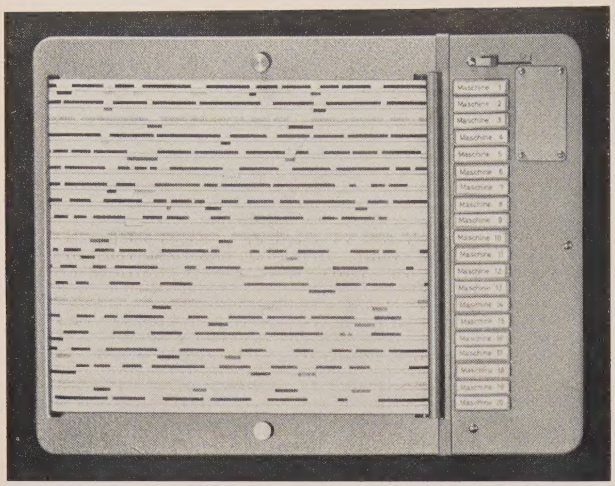

Fig. 4 40-channel recorder for monitoring the operating and downtimes of 20 machines

and thousands according to the output required. Here, too, direct observation and evaluation make it possible to avoid downtimes and so keep production flowing smoothly.

The state of machines (operation or interruption, depending on position of interruption switch) is indicated on a lamp panel at the center, where each machine is represented by six lamps. The attention of the attendant can in this way be drawn to the decisions that he is required to make.

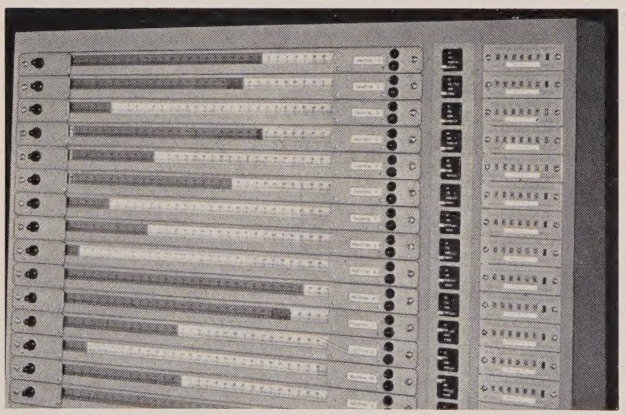

Fig. 5 Linear counter for monitoring completion of order

Analysis of data

Analysis of the data that is merged at the PRODUKTOGRAPH center permits instant decisions. The direct indication of the state of progress of individual orders allows direct provision for follow-up orders or order modifications. Work interruptions and their causes are instantly indicated on lamp panels at the center and registered by graphic recorders. It is in this way possible to institute immediate measures for the clearance of any fault.

Analysis of the indications and plots also permits long-term scheduling, checking of the utilization of machine capacities, realistic production control, acceleration of the flow of material, improvements in transport, inter-departmental performance comparisons, and the accumulation of statistics as a basis for long-term scheduling.

Beyond the applications already described – the creation of statistical records and data for payroll and cost accounting – the PRODUKTOGRAPH can also be linked with modern data processing systems such as the 2002 model [1] developed by Siemens & Halske.

It is by no means essential that the PRODUKTOGRAPH system and the data processing system should be located at the same site; if the data processing system of a large organization is located, say, at the offices of the management, it is readily possible for the data of the individual PRODUKTOGRAPH systems installed at the various factories to be transmitted to the data processing center over teletype circuits.

Data can in this way be transmitted over any distance to the data processing center. Where necessary, it can even be relayed through switching centers. If the transmission speeds used in teleprinting are too low, separate data transmission circuits can be established which, through the use of appropriately broad frequency bands, permit speeds up to 2,400 bauds.

The arithmetical results (payroll and cost accounting, unit prices) determined by the data processing system can be transmitted back over the same transmission systems and recorded at the respective factories in punched cards or tables, etc., where they will permit, say, the preparation of payrolls. A special Siemens selex system may here be used [2].

Layout of center

The systems are assembled from standardized electronic modules which can be arranged according to the respective requirements of the individual plants. The systems operate on 220/110 v, 48 to 62 cps and the modules on 24 v. The power supply voltage for the modules is regulated to guarantee proper functioning of the system even in the presence of power supply voltage fluctuations of ± 15%.

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Siemens Training Reactor SUR

By Günter Hildenbrand

Whilst most of the first research reactors were built as purely experimental projects, the present-day design of a research reactor is mainly governed by the purpose for which the reactor is intended. Although the fields of application of the research reactors are manifold, a reasonable survey can be obtained if they are classified in order of increasing output, starting with subcritical arrangements and small reactors for training purposes and progressing via small versatile experimental reactors and larger reactors for research purposes to the large high-flux reactors for materials testing.

In the development of nuclear reactor engineering, each type of research reactor has a specific contribution to make, whether it be for training or experimental purposes. Siemens-Schuckert have taken this condition into account with a manufacturing programme for research reactors suitable for a wide variety of applications. This programme was extended recently by a training reactor of type series SUR (Fig. 1).

Special problems with regard to teaching and training in the field of applied natural science are presented by the enormous increase in the subject matter to be covered and by the distinct trend towards specialization. A further problem is introduced by the more recent requirement that the general fundamental principles underlying a field be taught instead of a limited specialized subject. In this connection there are a number of arguments in favour of the use of small nuclear fission arrangements of subcritical or critical types in training or education centres for natural science and engineering. In brief, some of these are: The theoretical training will be incomplete unless it is substantiated by experimental demonstrations. The ever growing integration of science and engineering with the resultant intensification of team work makes necessary the adoption of a common language, as is illustrated admirably by the field of nuclear engineering. The special training in large reactor institutes will be the more fruitful the more the trainees are acquainted with the fundamental principles. However, large reactors are too expensive for basic training; they are not versatile enough and it is difficult to obtain an overall picture. In the Siemens-Schuckert training reactor SUR which has been developed on the basis of the experience gained in U.S.A. full account has been taken of these factors. It is a necessary compromise between a minimum of expenditure on the one hand and a maximum of versatility on the other. A high neutron density has been dispensed with and the reactor has been so designed that it can be installed in normal laboratory buildings without special

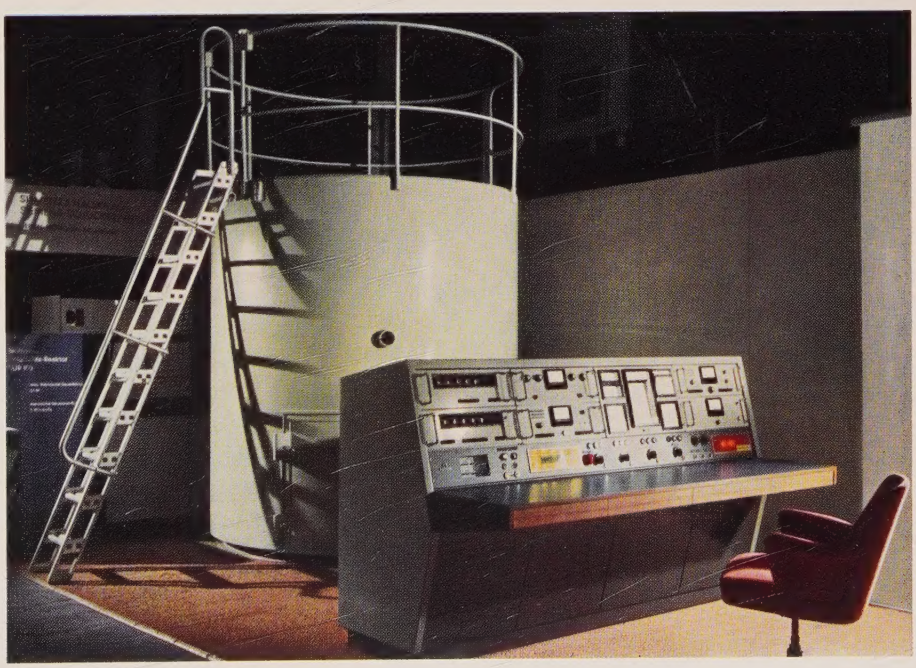
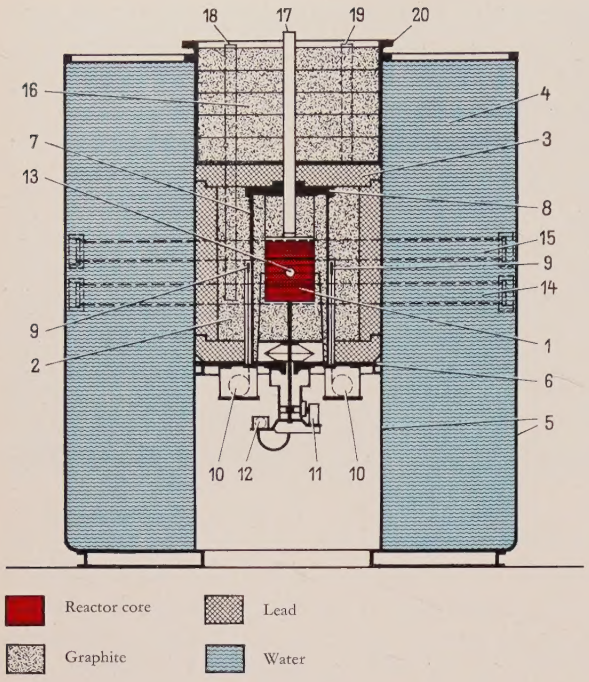


Fig. 1 Siemens training reactor SUR 100



1 Reactor core
2 Graphite reflector
3 Lead shielding
4 Water shielding
5 Outer reactor tank
6 Baseplate
7 Inner reactor tank
8 Aluminium cover
9 Control plate
10 Control plate drive
11 Hoisting winch for reactor core half
12 Neutron source drive
13 Horizontal central test hole
14, 15 Horizontal lateral test holes
16 Thermal column
17 Axial vertical test hole
18, 19 Side vertical test holes
20 Aluminium tank

Fig. 2 Section through the Siemens training reactor SUR 100

structural safety precautions and without creating a hazard to the immediate and remote surroundings of the reactor.

The construction of the reactor is shown in Fig. 2. The reactor core (1) consists of 24 cm dia. plates stacked to a height of about 26 cm. These plates are composed of a

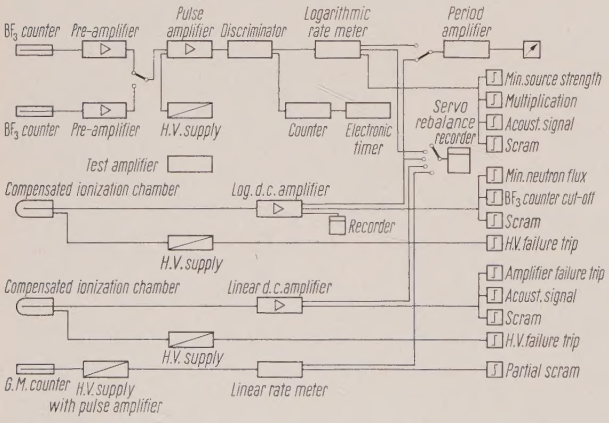


Fig. 3 Nuclear instrumentation of the SUR 100

compressed homogeneous mixture of U_3O_8 in powdered form as fuel and polyethylene as the moderator, whereby the uranium oxide is enriched to 20% with the fissionable isotope U^{235}. The critical mass is about 700 g of U^{235}. The reactor core is surrounded on all sides by a 20 cm thick graphite reflector (2). A 10 cm thick layer of lead (3) and a 60 cm thick water jacket (4), which contains boric acid as an additive, serve as shielding for the neutrons and gamma rays. The dose rate at a reactor power of 0.1 W is below the permissible limit of 2.5 mrem/h directly at the wall of the outer reactor tank (5).

The whole internal part of the reactor, including graphite and lead, is built up on a steel baseplate (6) which, in turn, is supported by a sectional ring welded to the inside of the outer reactor tank. The assembling space below the baseplate is accessible through a hinged door filled with water and an admixture of boric acid, which is recessed in the lower part of the outer reactor tank (see Fig. 1). In order to prevent gaseous fission products from leaking out, which by reason of the low reactor power are produced on an extremely small scale only, the reactor core together with a portion of the graphite reflector is housed inside a tight cylindrical aluminium vessel (7), the inner reactor tank. At the end of the critical experiment, during which the reactor core is made critical by the successive stacking of fuel/moderator plates of decreasing thickness, the inner reactor tank is sealed off with an aluminium cover (8).

In accordance with the special requirements for a training reactor, the SUR has two independent safety systems. The two control plates (9) which are built up of cadmium sheets as neutron absorbers and are located inside the graphite reflector but outside the inner reactor tank, can be moved rapidly by spring force from the bottom up to a point approximately in the centre plane of the reactor core to shut down the reactor. The lower part of the reactor core, together with the lower part of the graphite reflector, is then at the same time caused to drop by approximately 5 cm. In the critical experiment, the excess reactivity of the reactor, which depends on the fuel quantity and hence on the height of the reactor core, is fixed at 0.3 per cent. The insertion of the smaller one of the two control plates, the fine-control plate, reduces the reactivity by approximately 0.5 per cent, while the insertion of the other, the course-control plate, reduces it by approximately 1.5 per cent. The dropping of the lower reactor core half produces a decrease of approximately 5 per cent. Each of these facilities alone therefore suffices to safely shut down the reactor. The drives (10) of the two control plates consist of a winch mechanism which is operated from a geared motor via an electromagnetic clutch. On this drum is wound a leaf spring which, when stretched, is relaxed. The core winch mechanism (11) consists of a rack and pinion drive with geared motor and electromagnetic clutch. The moving ram is sealed against the inside of the inner reactor tank by means of

a diaphragm. Arranged inside the moving ram is the neutron source required for starting up the reactor. This is an Ra/Be source with an activity of 10 mC, which, on starting up of the reactor, is moved upwards to below the lower reactor core half by means of a flexible cable winch and a drive motor (12).

In addition to the safety systems described above, the reactor has a so-called inherent safety which is based solely on the arrangement and composition of the core. This utilizes the negative temperature coefficient of the reactivity which is approximately -3×10^4 per degree temperature rise. This means that, as a result of the limitation of the excess reactivity to 0.3 per cent, the reactor automatically becomes subcritical when the reactor core temperature increases by more than 10 degrees Celsius. As a safeguard against too low an operating temperature an interlock is provided for the reactor when the ambient temperature drops below 15 °C. A resistance thermometer is built into the reactor core and serves as a temperature detector.

The following experimental devices are provided in the SUR: three horizontal test holes (13, 14, 15) and a thermal column of graphite (16). Embodied in the latter are seven vertical test holes (17, 18, 19) of which one (17) is arranged in the centre line of the reactor, whereas the remaining six holes (18, 19) are arranged on a circle. The holes (17) and (18) extend down to the level of the upper and lower end of the reactor core, respectively, while the remaining five holes (19) run only within the thermal column. The horizontal test holes are closed from both ends with plugs of graphite, lead and polypropylene, the vertical holes being filled with graphite plugs. All plugs can be provided with recesses for accommodating the samples to be irradiated. The graphite of the thermal column is inserted in an aluminium vessel (20) in such a way that it can be easily removed and replaced by another moderator such as H_2O or D_2O.

The nuclear instrumentation (Fig. 3) indicates and supervises the operating condition of the reactor. It allows the neutron density to be measured at different points and signals to be transmitted by electronic trips to the switching devices of the electrical interlock system. In the start-up stage of the reactor the density is measured by a pulse chamber which can be connected to one of the two BF_3 neutron counters. The d.c. channels, which are each equipped with a compensated neutron ionization chamber, then come into action at a slightly increased reactor power. In addition to the neutron density which is measured either logarithmically or linearly, the reactor period is determined via a differential amplifier. This provides a direct criterion for the rate of change of the neutron density, thus providing an important indication of the reactor behaviour. Finally, a test hole fitted with a gamma counter measures and supervises the gamma dose rate in the immediate proximity of the reactor.

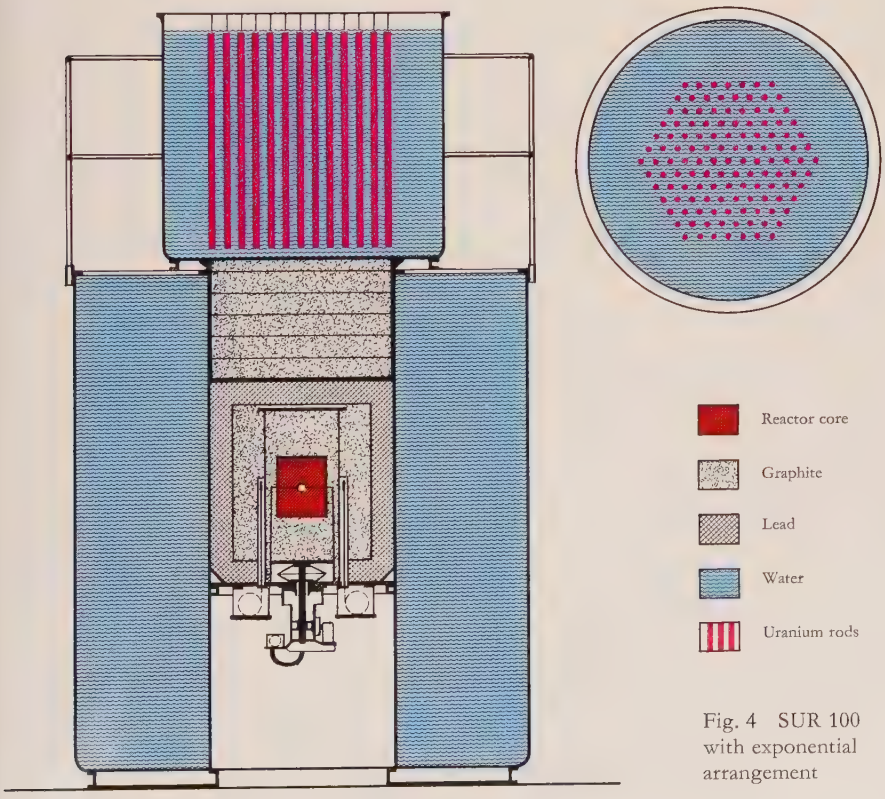


Fig. 4 SUR 100 with exponential arrangement

Through the medium of an interlock system, the general electrical instrumentation of the reactor ensures that any erroneous operations have no effect and that the reactor is automatically and dependably shut down if certain anti-radiation measures are not taken or if technical faults such as the failure of essential auxiliaries of the nuclear instrumentation occur. Inadmissible operating conditions likewise cause a shutdown. The entire electrical instrumentation is accommodated in a separate control desk. All operating buttons are within easy reach of the operator and all indicating instruments are easy to read without impairing the view of the reactor (see Fig. 1).

The SUR is available in three designs which are generally distinguished only by the thickness of the shielding.

With a continuous power of 0.1 W the SUR 100 has a maximum thermal neutron density of 5×10^6 n/cm^2-s. In the case of types SUR 1000 and SUR 10000, the reinforcement of the shielding by concrete blocks (stacked around the outer reactor tank) permits continuous operation at a thermal power of 1 and 10 W and a maximum thermal neutron density of 5×10^7 and 5×10^8 n/cm^2-s respectively.

In accordance with the type of construction, the reactor is applied for training and education, the reactor being used on the one hand as a visual instruction and training object and on the other as a measuring device and radiation source. By handling the reactor and starting it, the student is in the first case made familiar with the fundamental construction and the operational behaviour of reactors. By performing simple experiments such as the calibration of the control plates, the determination of the excess reactivity, the measurement of the last group of delayed neutrons, the neutron density and its distribution, etc., he learns how to determine the principal characteristic data of the reactor. By comparison of the results of measurements with the theoretical values, understanding of the general relationships is furthered, especially as the simple construction of this reactor permits experimental comparison with the theory underlying it, without involving complicated mathematics. In the second case it is possible to determine the cross-sections of various materials for neutron absorption and dispersion, the moderator characteristics and other quantities of neutron physics, as well as the activation of isotopes. It also allows the student to familiarize himself with the basic measurements of, and precautions against, ionizing radiation.

As experience has shown, a small reactor is a valuable auxiliary, particularly for a practical course on radiation measuring techniques. The short-lived isotopes which can be sufficiently activated in this reactor offer the advantage that their activity decays after a short time so that the danger of the laboratory being contaminated due to careless handling of the samples is practically eliminated. Table 1 contains figures from an activation table of the elements which can be activated with the SUR 100. The specific activities apply for one hour of irradiation in the horizontal central test hole of the reactor. The maximum masses indicate the maximum mass of the substance which can be inserted in this test hole. These are determined by the condition that upon the insertion of the substances the reactor must not go subcritical. In view of the fact that activities as low as 0.01 μC can still be detected, approximately 60 elements can be sufficiently activated in the central test hole of the SUR 100.

Atomic number Z	Element	Atomic weight M	Half-life t_H	Specific activity (1 h) μC/g	Max. mass g
13	Al	27	2.3 min	0.66	250
23	V	51	3.76 min	7.0	40
25	Mn	55	2.58 h	4.6	17
45	Rh	103	4.4 min	8.0	2.75
47	Ag	107	2.3 min	12.5	7
49	In	115	54 min	55.0	2.5
63	Eu	151	9.2 h	4.1	0.15
66	Dy	164	2.3 h	65.0	0.7
71	Lu	175	3.7 h	2.3	6
77	Ir	193	19 h	1.2	1.8
79	Au	197	2.7 d	0.2	8

Table 1 Examples for activating isotopes in the SUR 100

An extensive instruction manual with the fundamental principles and corresponding experiments for a practical course is intended to promote the use of the reactor as a training device. Suitable supplementary devices extend its field of application. The supplementary devices include a pile oscillator which is inserted in the central test hole and is used for measuring capture cross-sections.

In this connection attention is drawn to the use of the SUR as a plane thermal neutron source for carrying out instructional exponential experiments. In this case a tank filled with water, in which rods of natural uranium in a regular lattice arrangement are immersed, is placed on the thermal column of the SUR (Fig. 4). It is then possible to measure important characteristic data of the lattice arrangement. The flexibility of the lattice arrangement provided by the possibility of varying the distances between the rods and by their symmetrical arrangement makes for a much desired improvement in training.

As already mentioned, a reactor such as the SUR can be installed in any normal laboratory without the need for structural alterations; this is made possible by the absence of cooling-water circuits and exhaust air problems. The fixed running costs are low. Since the annual lease charge for fuel amounts only to about DM 2,000.– and since the annual fuel consumption of approximately 30 micrograms of U^{235} (in continuous operation) is negligible the running costs are mainly determined by the outlay for wages and salaries. Generally, no special allowance need be made for this since staff capable of accepting responsibility for the reactor will in any case most likely be available in all education centres such as universities, technological institutes and technical colleges.

The first Siemens SUR training reactor with which the prospective buyers can familiarize themselves before their own is delivered will be put into operation in a few months in the Siemens-Schuckertwerke reactor station at Garching near München, where the Siemens Argonaut reactor SAR has been operating since June 1959.

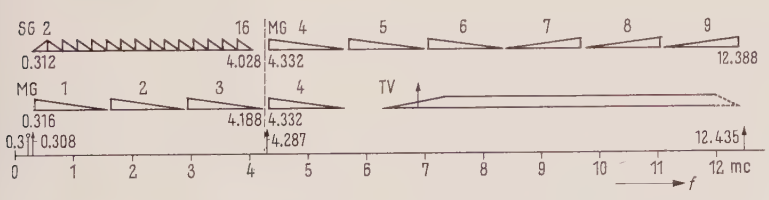
Line Equipment of 12-Mc Carrier System

By Kurt Barthel and Werner Zitzmann

Siemens & Halske AG constructed their first coaxial cable system during the mid-thirties and at around the same time the first coaxial cables were laid in the U.S.A., England and Germany. Coaxial cable systems today play an important part in the communications networks of countries with highly developed communications media [1]. They are of particular advantage where large groups of communications channels have to be run over long routes.

Advances in repeater technology have been followed by the introduction of systems with increasingly broad frequency bands. It has in this way been possible to satisfy the steadily growing demand for speech circuits in an economic manner. Thus Siemens & Halske followed up its B-200 system (200 telephone channels + 1 tv channel with a bandwidth of 3 mc) with the development of a 4-mc system (960 telephone channels or 1 tv channel) and a 6-mc system (1,260 telephone channels or 1 tv channel). The newest member of this family is a 12-mc system, the equipment of which has already been placed in quantity production.

The frequency allocation of the 12-mc system, which furnishes either 2,700 telephone channels or 1,200 telephone channels and 1 tv channel, was specified by the CCITT (Fig. 1) taking account of the following considerations: organic coordination of modulating equipment and carrier supply bay, simple facilities for dropping channel groups, and facilities for the simultaneous transmission of telephone and tv signals over the same line. The frequency range up to 4 mc can be assigned either to the supergroups 2 through 16 (with 60 telephone channels each) as in the 4-mc system, or to the master groups 1 through 3 (with 300 channels each). This applies both to when the system is operated with telephone channels only and to when it is operated with telephone and tv channels. Above 4 mc there are then either the master groups 4 through 9 or the master group 4 and a tv channel. The telephone channels begin at 312 kc and end at 12,388 kc; the line pilots are located at 308, 4,287 and 12,435 kc. A pilot serving for frequency comparison of the carrier generators of the network is transmitted at 300 kc.



SG Supergroup (60 telephone channels)
MG Master group (300 telephone channels)
TV Television channel

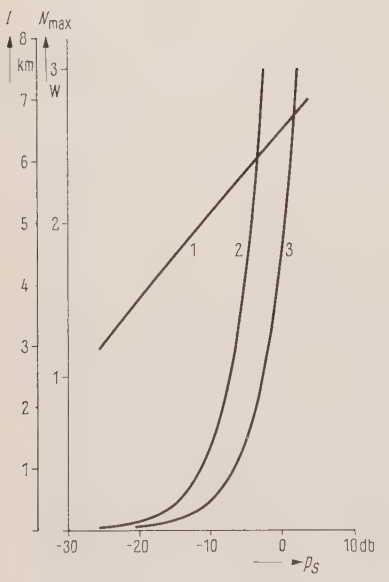
Fig. 1 Frequency allocation of 12-mc system

Transmission route

For the 12-mc system the CCITT issued recommendations for a reference circuit of 2,500 km in length with several different stages of translation. This reference circuit is subdivided into nine sections of equal length. The requirements to be met by the individual units of equipment can be inferred from the recommendations.

The route is assigned two respective coaxial tubes for the two directions of conversation, and amplifier equipment. The dimensions of the coaxial tube are standardized: the outer diameter of the inner conductor is about 2.6 mm, the inner diameter of the outer conductor about 9.5 mm. The attenuation amounts to 0.932 nepers/km (8.107 db/km) at 10 deg C and 12 mc, and 0.146 nepers/km (1.290 db/km) at 300 kc. The attenuation as a function of frequency approximately follows the law $\alpha \approx c\sqrt{f}$, i.e. the attenuation rises with the square root of the frequency. It depends not only on the length of the line and the frequency, but also on the cable temperature. The variations in attenuation induced by temperature changes amount to 0.2% per °C and act upon the attenuation in the same manner as variations in length. The group delay of the line differs according to the frequency of the signal; delay differences must be equalized in the case of tv transmission.

Line attenuation and its fluctuation are eliminated by variable-gain repeaters spaced at certain intervals along the line. The repeater spans depend on the transmitting power of the amplifier, i.e. on the maximum transmitting level of the topmost channel and the minimum receiving level, which is determined by the noise in the resistors and tubes. Fig. 2 shows various curves giving the repeater spans and maximum power of the amplifier as a function of the transmitting level of the topmost channel. The required power rises very sharply as soon

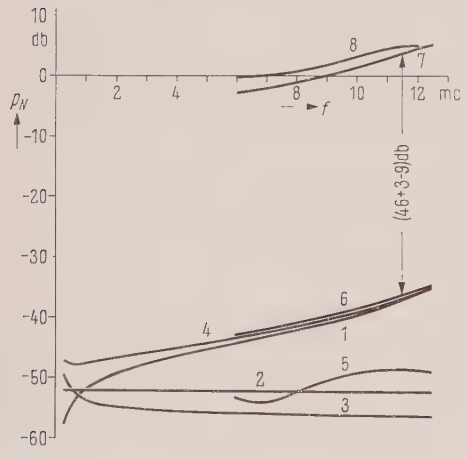


Curve 1 $l = f(p_s)$;
p_s Transmitting level of topmost channel
Curve 2 $N_{max} = f(p_s)$ without preemphasis
Curve 3 $N_{max} = f(p_s)$ Preemphasis 7 db (0.8 nepers)
N_{max} is the amplifier power (+ 6 db reserve) required for 2,700 telephone channels according to CCITT on account of overload

Fig. 2 Repeater span l and amplifier power N_{max} as function of transmitting level p_S

as certain repeater spans or transmitting levels are exceeded. For the 12-mc system a design center span of 4.65 km and a maximum repeater span of 5 km were chosen, i.e. half the repeater span of the 4-mc and 6-mc systems. For the channel with the highest transmitting frequency this results, as we see from Fig. 2, in a relative transmitting level of –13 db (–1.5 nepers) at the output of the amplifier.

The CCITT recommended that the noise power in a telephone channel in the reference circuit should not be allowed to rise above 10,000 picowatts. Of this value, 2,500 picowatts are allocated to the modulators and the balance of 7,500 picowatts to the line equipment. The noise consists not only of the resistor and tube noise already mentioned, but a considerable proportion is due to the nonlinearity of the amplifiers. Harmonics, as well as sum and difference tones of speech and dialing signals, reenter the telephone channels as intermodulation noise. A preemphasis network inserted preceding the transmitting amplifier in order to improve the signal-to-noise ratio is so chosen that the relative transmitting level of the bottommost channel is reduced by 7 db to –20 dbr. Exacting requirements have to be placed with respect to the linearity of the amplifiers in order to maintain the intermodulation noise within the admissible limits. Thus, with the chosen preemphasis taken into account, the second-order harmonic distortion for an amplifier with an output network of constant attenuation must be at least 93.5 db at 0.3 mc and at least 83 db at 12 mc, and the third-order harmonic distortion must be at least 126 db and 121 db at the two respective frequencies. Provided that the entire band is allocated to telephone channels, it would be just possible to satisfy the CCITT recommendations with this level of harmonic distortion.



Curve 1 Noise power level at output of 540th line amplifier E
Curve 2 Noise power level at output of 105th line amplifier G
Curve 3 Noise power level at output of 35th line equalizer D
Curve 4 Sum of noise powers (level) of curves 1, 2, 3
Curve 5 Sum of noise powers (level) of tv branch (fully regulated station)
Curve 6 Sum of noise powers (level) of curves 4, 5
Curve 7 Level curve at (46 + 3 – 9) db from curve 6
Curve 8 TV power level for picture content

Fig. 3 Noise power level of line equipment for reference circuit and a bandwidth of 5 mc

What is the situation, however, where telephone calls and a tv program are transmitted simultaneously? Fig. 3 shows the noise powers of the line for the reference circuit and a frequency bandwidth of 5 mc. Along with the sum curve 6, representing all the noise powers, a parallel curve 7 was drawn at an interval of [46 + 3 – 9] db = 40 db. The value 46 db is the ratio of the peak-to-peak picture signal to the rms noise recommended by the CCITT; the value 3 db takes into account an even distribution of noise between modulator and line, and the value 9 db corresponds to 20 log $2\sqrt{2}$ (conversion of peak-to-peak value to rms value). The tv level must lie above this curve. For television a power level as shown in curve 8 with a preemphasis of 5 db was chosen. The level in the vicinity of the 6,799-kc tv carrier thus amounts at the amplifier output to 0 dbm for an all-white picture. A relative transmitting level of –13 db without preemphasis was provided for the 1,200 telephone channels.

Noise in telephone channels when operated together with tv

The difference waves between the tv carrier and the tv sideband, which is composed of multiples of the horizontal frequency, are particularly disturbing. For moving tv scenes – the spectral power distribution of which is quoted from a paper by RITTERMANN [2] – it is necessary in the case of a 280-km repeater span ($^1/_9$ of reference circuit) and the already mentioned a_{K2} minimum values and the preemphasis indicated in Fig. 3 to reckon with an additional noise power of about 500 to 2,000 picowatts. These values are already too high but become appreciably higher if a stationary electronic test pattern is transmitted

with a more strongly concentrated energy distribution than moving scenes. Calculated with a sinewave as picture content, the maximum noise power in a telephone channel due to television increases fourfold at low frequencies and by the factor of the tv preemphasis at high frequencies. The minimum values for a_{K2} allowed for telephony will therefore not be utilized. Better values must here be obtained and suitable voltages chosen for the electronic test pattern so as to minimize the noise power. In marginal cases the noise in telephone channels can be reduced to zero for the various frequencies of an electronic test pattern by choosing the picture voltage and brightness so that the carrier voltage is zero. This is possible with tv transmission over cable because the depth of modulation here applied is more than 100% (ECR = 0.65) [3]. These deliberations show that the harmonic distortion of the amplifiers must not be calculated merely according to the requirements that exist when the 12-mc system is used exclusively for telephony, but also taking account of the noise in the telephone channels in cases where telephone calls are transmitted along with a tv program. In the Siemens system the noise power in the telephone channels remains between 90 and 360 picowatts when moving scenes are transmitted in the tv channel; these noise powers lie far below the admissible maximum values.

Noise in tv channel

Calculations of the second-order and third-order combination tones from the tv carrier level and the speech signals in the various channels yield, with the actually existing values a_{K2} and a_{K3} for the ratio of the peak-to-peak difference-tone voltage, values of 60 db or more in the vicinity of the tv carrier. At higher frequencies the ratio is better by the tv preemphasis, hence by 5 db. For the purpose of calculation it was assumed that the disturbing telephone channel runs for 2,500 km in the same position within the frequency band and that its power level amounts to 0 dbm at the relative level 0. Despite these extremely adverse assumptions, the signal-to-noise ratios > 60 to 65 db are satisfactory. If, however, the power level per telephone channel at the relative level 0 is reckoned at –15 dbm such as is customary in noise calculations, signal-to-noise ratios of 75 to 80 db result. The noise in the tv channel is accordingly far easier to override than noise in telephone channels.

Noise in telephone channels

Fig. 4 shows measured data and guaranteed values for the harmonic distortion of the 12-mc amplifier and Fig. 5 the noise powers calculated from the measured data of the line equipment for the 2,500-km reference circuit and the rated level when the 12-mc system is used exclusively for telephony. The relative transmitting level of the topmost channel amounts to –13 db; the level of the other channels is reduced by a preemphasis network which can be represented by the expression $e^{-2\Delta p}\ (1 + \alpha\, e^{k\Omega})$. $\Delta p = 0.8$ nepers (6.95 db), $\alpha = 0.01277$, and $k = 5.735$ should here be entered; Ω is the normalized frequency. The bottom channels have, as already stated, a relative transmitting level of –20 db. As may be seen from Fig. 5, the noise powers lie far below the maximum value allowed by the CCITT.

Line amplifiers

Two types of line amplifiers are used in the 12-mc system: the line amplifier E (equalizing type), which offsets the cable attenuation at intervals of approx. 4.5 km, and the line amplifier G (flat frequency response), which serves at the beginning of the line as a transmitting amplifier and at fully regulated intermediate repeater stations for equalizing the basic attenuation of equalizers and filters.

The line amplifier E (Fig. 6) is a three-stage model, two tubes being connected in parallel in each stage. As only one tube in each stage need be in working order to insure operation, and the probability that both the tubes of a

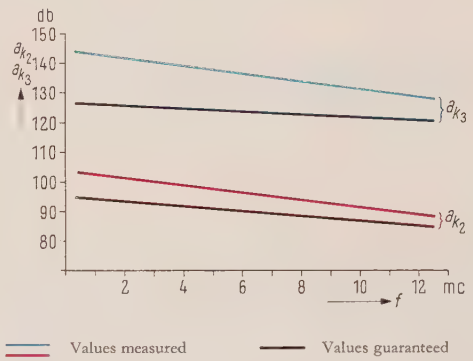
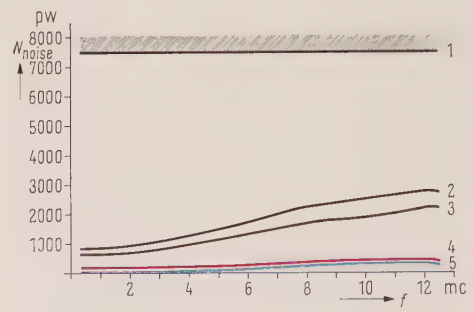


Fig. 4 Harmonic distortion of line amplifier E



Curve 1 Noise power allowed by CCITT
Curve 2 Sum of noise powers (curves (3 + 4 + 5)
Curve 3 Noise power due to thermal noise
Curve 4 Intermodulation noise power due to products of second-order harmonic distortion
Curve 5 Intermodulation noise power due to products of third-order harmonic distortion

Fig. 5 Noise powers of line equipment for reference circuit and a bandwidth of 3,100 cps

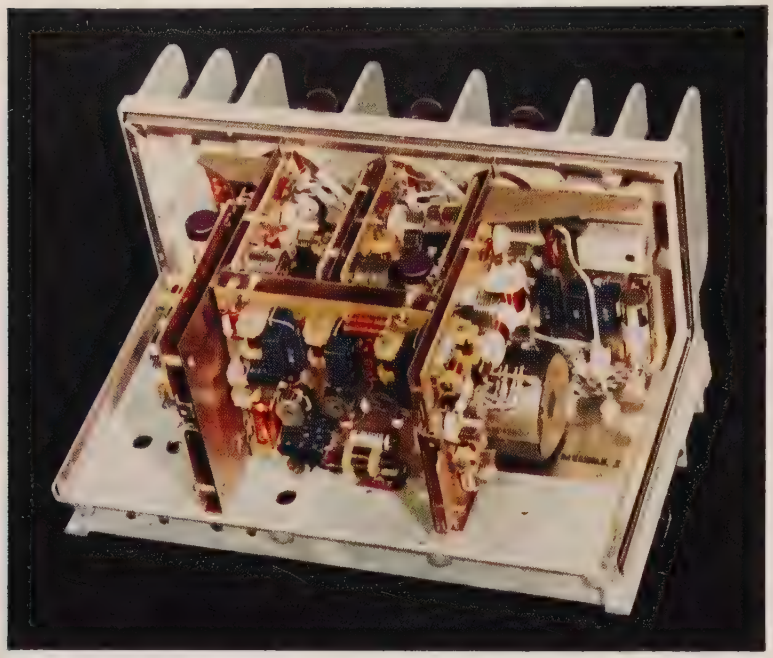


Fig. 6 Line amplifier E

stage will fail simultaneously is small, extremely high operating reliability is guaranteed. The failure rate referred to 1,000 hours is, in the case of parallel-connected tubes, lower by the factor of 1,000 than with single tubes and thus similar to that of highly reliable coils and capacitors [4]. It is for this reason not necessary to provide a standby amplifier with automatic changeover feature that is continuously ready for service.

The possibility of designing the line amplifier E with only three tube stages is due to the good characteristics of the D 3a tube developed by Siemens & Halske for the 12-mc system [5]. The D 3a has a mutual conductance of 35,000 μmho for an anode current of 22 ma, a maximum usable frequency of 230 mc, and an equivalent noise resistance of 150 ohms.

The use of only three stages secures the advantage that the amplifier has to embody only four networks that determine the frequency response of the gain, viz. input and output transformer networks, preequalizer and degenerative networks. In the four-stage amplifier today widely used in broadband systems, six or seven networks act upon the frequency response. The trimming work that has to be performed on the four-stage amplifier is thus more extensive and the inaccuracy of the frequency response of the gain is greater. The use of three-stage amplifiers additionally means a saving in components, as well as of about 30% in tubes, so reducing operating costs and at the same time improving operating reliability.

Fig. 7 shows the basic circuit diagram of the line amplifier E. The frequency response of the input transformer network rises towards the high end of the spectrum, whereas the output transformer network exhibits constant attenuation. Both are designed as bridge networks in order to secure good impedance matching. At the input and output of the amplifier the reflection coefficients with respect to 75 ohms are less than 10% throughout the frequency range. The second output of the output transformer network acts as a pilot output. The degenerative coupling of the loop of about 23 db and that of the power stage itself of about 14 db secure high linearity (see Fig. 4). The degenerative network in the cathode circuit of the first and third tube stages contains a thermistor whose variations in resistance act upon the frequency reponse of the gain according to root law (Fig. 8). Through the action of the preequalizer the gain for two certain curves is brought to within ±0.1 db of the cable attenuation.

The line amplifier G operates with two tube stages and satisfies the same exacting requirements as the line amplifier E with respect to linearity and reflection coefficients.

Equalization

The main portion of the cable attenuation is offset by the line amplifier E, which also offsets the temperature response of the cable attenuation. To secure automatic equalization, a 4,287-kc line pilot is injected at the transmitting station. At what are termed semi-regulated repeater stations, pilot receivers are connected to the second output of the line amplifiers E for segregating and rectifying the pilot and comparing it with a nominal voltage. If the pilot does not coincide with the nominal voltage, the difference voltage acts upon the heating current of the thermistor by way of an automatic control

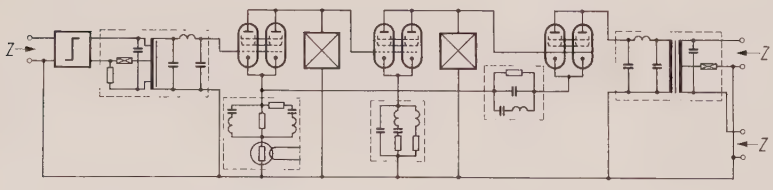


Fig. 7 Basic circuit diagram of line amplifier E

feature and adjusts the gain of the line amplifier E until the pilot voltage is correct and the difference voltage becomes zero. This automatic control action takes place at every other semi-regulated repeater station. At the other repeater stations the pilot receiver serves only for monitoring. The absence of the pilot or any sudden drop in pilot voltage by 3 to 5 db or more is remotely indicated to the next fully regulated station. The automatically regulated repeater stations likewise indicate this fault condition but, instead of continuing regulation, stop at the last selected gain curve according to the rule that faults in the pilot system must not be allowed to interrupt transmission.

From the operational standpoint there is no good reason why the line pilot should be transmitted over thousands of miles. It is, for instance, of no interest to the PTT administration in Stockholm if a pilot fails in Rome. The regulated sections should not, on the other hand, be too short because the errors of regulation occurring in each section are liable to be additive. If the length of a regulated section is set at 300 to 500 km, which means that the pilot is blocked and newly injected after every 300 to 500 km, the section will require from 65 to 110 line amplifiers E, about half of which – from 32 to 55 – are automatically regulated. To prevent disturbing overshoots in cases where so many identical regulators are cascaded, the regulating behavior of the individual regulator is required to meet high standards [6]. Such standards are best met with a proportional-integral regulator. The pilot generators and pilot receivers (Fig. 9) are equipped with transistors as active components, whereas regulators are equipped with magnetic amplifiers.

24 semi-regulated repeater stations at the most (approx. 115 km) must be followed by a fully-regulated repeater station, from where they – twelve in either direction – are remote-powered. As the attenuation distortion may rise in the interim to a few decibels, fine equalization is here required as well. Once the line has been accurately equalized at the outset it should not be readjusted manually but maintained in an unchanging state by automatic control. A knowledge of the effects that induce change is here necessary. Such effects are the aging of tubes and the changing temperature of the equipment. As the variations in gain due to these effects are considerably lower than the temperature response of the cable attenuation, they need only be offset at fully regulated repeater stations. This is accomplished by the two pilots 12,435 kc and 308 kc with their appropriate pilot generators, pilot receivers, regulators, and tube-aging and temperature equalizers (Fig. 10).

Besides these pilot-controlled equalizers, several variable equalizers are required such as the building-out network preceding the line amplifier E with which repeater spans that are too short are brought into the regulating range of the amplifiers. Where necessary, they are also used in semi-regulated repeater stations for simulating cable lengths of 0.2 km and more in steps of 0.2 km up to about half the length of the repeater span.

A further equalizer is provided to offset the systematic errors that arise due to the degeneration-loop equalizers in line amplifier E. These equalizers are two-pole networks which do not allow the establishment of proportional curves by adjusting a rheostat. As already stated, attenuation and gain coincide exactly (±0.1 db) for only two certain curves. In the case of the other selectable values there is a residual error which can be determined in advance and is offset by the variable equalizer for systematic error. The equalizer consists of only a few elements.

Following the operation of these equalizers, only slight residual distortions remain and these are largely offset by the line equalizer D. This equalizer is designed to operate

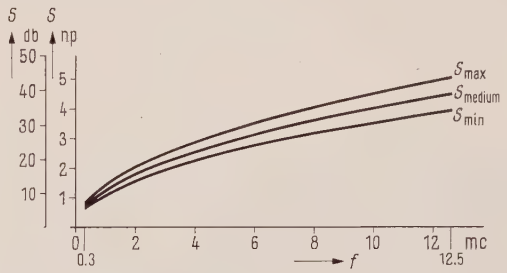


Fig. 8 Gain of line amplifier E as a function of frequency

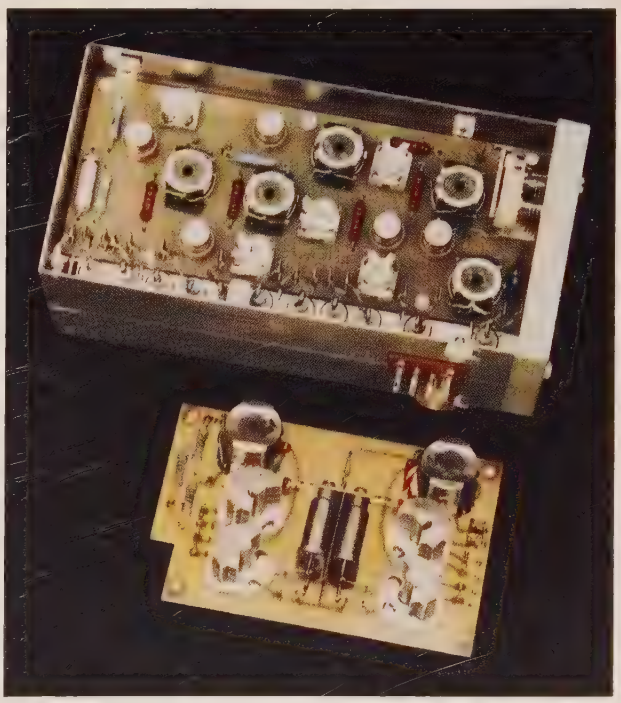
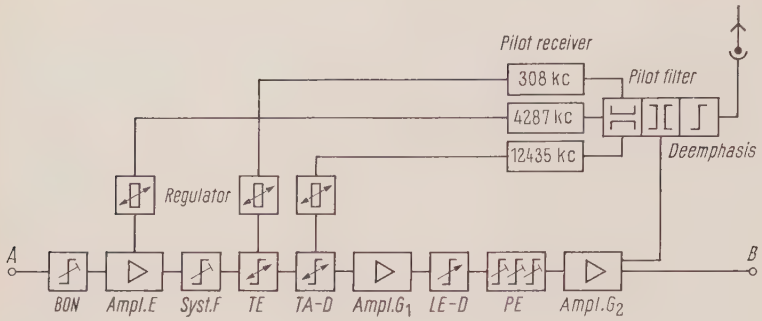


Fig. 9 Pilot receiver with 4,287-kc pilot filter



BON Building-out network
TE Temperature equalizer
LE-D Line equalizer D
Syst.F Equalizer for systematic errors
TAF Tube-aging equalizer
PE Pilot equalizer
MO Measuring output

Fig. 10 Simplified block schematic showing equalization at fully regulated repeater station

on the echo principle and permits up to 34 lagging echos to be added to the main signal or, in other words, permits the selection of 34 cosine-shaped attenuation curves in the frequency range up to 12.5 mc, whereby the first yields half a cosine wave. With the aid of the cosine-shaped attenuation curves any frequency response of the gain can be offset within the given limits [3]. As this equalizer serves for mop-up equalization, it is considerably more elaborate than the one for systematic errors.

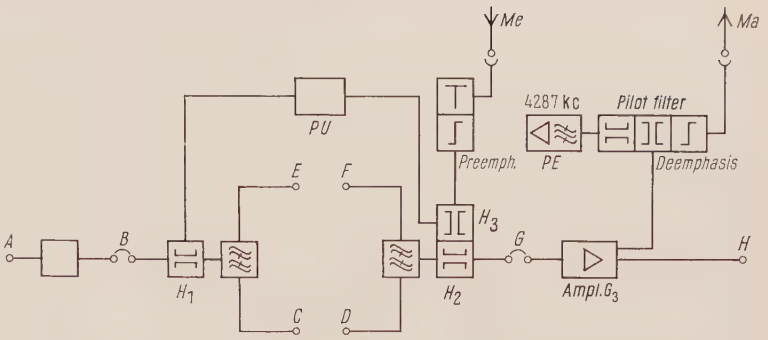
Assume that the frequency response of the attenuation of the given line section is to be equalized to, say, ±0.5 db with the means already described. It may here occur that the voltages of the line pilots deviate by this tolerance from the nominal value, and hence lie at just +0.5 db or –0.5 db. It is, however, desired that the line pilots should be passed on to the next line section with their correct value. This may be accomplished by inserting a pilot equalizer permitting accurate adjustment of the attenuation at the pilot frequencies.

If the system is used for telephony and television together, the fully regulated repeater stations are assigned the same equalizer equipment as just described. This is followed by a separating filter that separates the telephone band from the tv band. The tv band can in this way be equalized separately. This is also essential because television places somewhat more exacting requirements with respect to the equalization of attenuation and, above all, demands satisfactory delay equalization. Both requirements are met by an attenuation equalizer along with one fixed and one variable delay equalizer. Two station-cable equalizers for go and return are also provided, because the supplementary tv bay accommodating the filter and equalizers can be installed separately from the line amplifier bay for fully regulated repeater stations.

Fig. 11 Line amplifier bay (1.5 m) for a semi-regulated repeater station

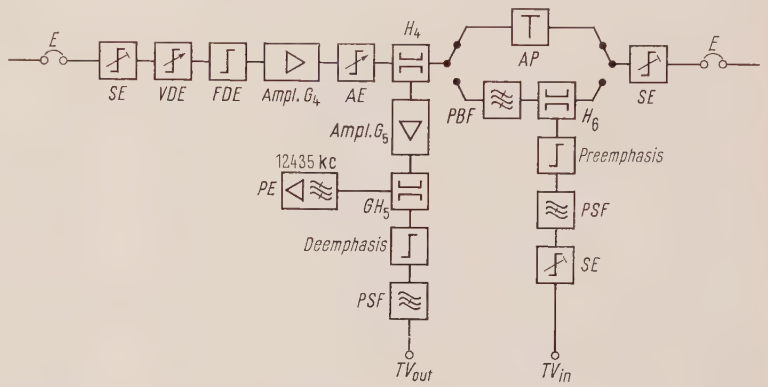
Depending on the number of repeater spans between two fully regulated repeater stations, the fixed delay equalizer will be composed of from one to four delay equalizer units or simulating delay networks. The delay of a line section with 4 to 28 repeater spans can be equalized with the delay equalizers for 1 repeater span, for 26 repeater spans, for 1 fully regulated station, and with the simulating delay networks for 1, 4, 9 and 17 repeater spans. Any residual delay is eliminated by the variable delay equalizer, which, like the line equalizer D, although designed as an equalizer, is effective only in the range from about 6 to 12.5 mc. As the equalizer is a minimum-phase network, only the delay and not the attenuation distortion should be considered when it is set. Following such equalization, residual attenuation distortions are mopped up by the attenuation equalizer. This variable equalizer likewise operates on the echo principle but with leading and lagging echos that are coupled in such a way that cosine-shaped attenuation curves can be produced with constant delay. Equalization of attenuation is accomplished without affecting the already equalized frequency response of the delay.

Although the enumeration of so many different equalizers may perhaps give the impression that equalization is difficult, experience has shown the handling of equalizers, which are of course installed only at intervals of about 100 km, to be a relatively simple matter. In a regulated section it is readily possible to equalize the attenuation in the telephone band to less than ±1 db, that in the tv band to less than ±0.5 db, and the delay to less than ±50 nanoseconds.



H_1, H_2, H_3 Hybrid transformer
PE Pilot receiver
PU Pilot bypass circuit
Me Measuring input
Ma Measuring output

Fig. 12 Simplified block schematic for line amplifier bay at fully regulated repeater station



SE Station-cable equalizer
AP Attenuator pad
AE Attenuation equalizer
FDE Fixed delay equalizer
VDE Variable delay equalizer
H_4, H_5, H_6 Hybrid transformer
PBF Pilot bandpass filter
PSF Pilot stop filter

Fig. 13 Simplified block schematic for supplementary tv bay

Repeater stations

Semi-regulated repeater stations are by far in the majority along the line and must therefore be simple in design and reliable in operation. The amplifier equipment for the go and return directions is accommodated in a bay 1.5 m in height (Fig. 11).

The measuring chassis permits the measurement of the operating voltages and currents of the various tubes; the voltage between grid and cathode can be measured under conditions of normal heating and underheating. The voltage difference indicates whether a tube is still capable of proper operation. If the difference exceeds a specified value, the tube may be concluded to be near the rejection limit and must be checked in the test set. This method avoids the unnecessary extraction, measurement and reinsertion of tubes.

The pilot receiver chassis 4,287 kc embodies an indicating assembly, two regulator assemblies, and a regular/standby switch for the line amplifier E. The standby amplifier can be cut in without any interruption in service. This is only necessary, however, when a regular amplifier occasionally has to be checked.

The bay shown in Fig. 11 is designed for stations where the power supply filters, the remote-powering transformers, and the other remote-powering devices are accommodated in a separate bay. It will be seen from the photograph that the bay has sufficient room to accommodate these devices as well. This possibility has been made use of in another layout plan not here shown.

Whereas identical devices for telephone operation only and for mixed telephone and tv operation are installed at semi-regulated repeater stations, those installed at fully regulated repeater stations differ greatly according to the type of operation. In the case of mixed telephone and tv operation, the television band must be separated from the telephone band by separating filters and additionally equalized in the manner described. There are also fully regulated repeater stations for dropping the tv band and groups of telephone channels.

In order to limit the number of types of bays, a line amplifier bay has been chosen which is capable of holding all the equipment required at terminal stations and fully regulated repeater stations except for the delay equalization equipment in the case of mixed telephone and tv operation and the devices for dropping sub-bands. By changing some of its chassis units, this bay can also be adapted for telephone operation only. The separating filters, for instance, can be replaced by attenuator pads and other units. For the two directions of transmission of a system, a terminal station requires only one 2.6-m bay, while a fully regulated repeater station requires two bays. A further bay, the supplementary tv bay, holds all the equipment required for equalizing the tv section and, if necessary, the equipment for dropping and injecting tv bands. A third bay, the dropout bay, holds the equipment for dropping groups of telephone channels.

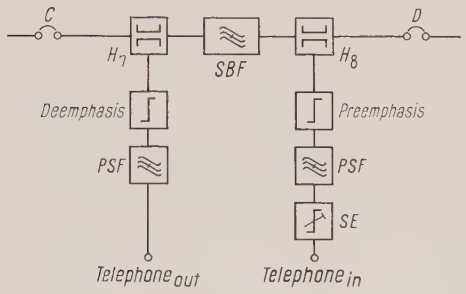
The line amplifier bay used for mixed telephone and tv operation at fully regulated repeater stations holds about

the same equipment as that seen in Fig. 12. The box drawn between points A and B is represented in detail in Fig. 10. The hybrid transformers H_1 and H_2 serve for extending the pilots that are stopped through the insertion of the dropout device in the transmission path. The length of regulated sections may thus be chosen purely from the aspects of regulation and operation, and independent of the dropout technique. The hybrid transformer H_3 can be used to inject measuring pilots and, at the beginning of a new regulating section, regulating pilots. The pilot generators are naturally installed only at the beginning of a regulated section. The line amplifier G_3 offsets the attenuation of 30 db between points B and G. At the terminal stations the equipment in the line amplifier bay is used between points A, C and E as receiving amplifier equipment and between points D, F and H as transmitting amplifier equipment.

Fig. 13 shows the simplified block schematic of the supplementary tv bay for insertion between points E and F in Fig. 12 . Two respective station-cable equalizers SE are connected to the input and output of the bay so that it can, if necessary, also be installed separate from the line amplifier bay. The hybrid H_4 is used to drop the tv channel. A pilot receiver is connected to the hybrid H_5 for monitoring the two line amplifiers G. A deemphasis network and a pilot filter for 12,435 kc are connected preceding the output TV_{out}. The main transmission path runs from the hybrid H_4, through a transfer switch – with interposed attenuator pad –, to the station-cable equalizer SE and from there to the output.

If a tv program is to be injected at the station, it is fed from the input terminals TV_{in} through a station-cable equalizer and a pilot stop filter to hybrid H_6. A pilot bandpass filter preceding the hybrid in the main transmission path passes only the 12,435-kc pilot and not the tv program.

Fig. 14 shows the dropping of telephone channels and the replenishment of the line by a new band in place of the one dropped. The graphic representation covers only one direction of transmission; identical equipment is used for the other direction. Channel-dropping is effected by way of the hybrid H_7, the deemphasis network and the pilot stop filter preceding the stop band filter. At the output TELEPHONE_{out}, all the dropped channels have the level of –32 dbr recommended by the CCITT. Channel-replenishment is possible in the outgoing direction. Injection is through the input TELEPHONE_{in}, the station-cable equalizer, the pilot stop filter and the preemphasis network. Following the station-cable equalizer the power level of all channels is –35 dbr, which conforms to the values recommended by the CCITT. A stop band filter inserted between the hybrids H_7 and H_8 passes the sub-band that is to be extended and blocks the frequency band that is to be dropped. It is practical to use the master groups 1 through 3 or 7 through 9 for dropping and replenishment.



SBF Stop band filter
PSF Pilot stop filter
H_7, H_8 Hybrid transformer
SE Station-cable equalizer

Fig. 14 Simplified block schematic for dropout bay

It should be added in the interest of completeness that dropping and replenishment can also be accomplished by other means. It is possible, for instance, to split the overall band into three basic supermaster groups (the master groups 7 through 9 represent a basic supermaster group) by appropriate demodulation and, after they have passed through supermaster group filters, reconstitute them as the transmission band.

The advantages and drawbacks of the various potentialities will not here be gone into; the solution indicated in the diagram is one that finds frequent application. Through appropriate interconnection of the arrangements shown in Figs. 12, 13, 14 it is possible to drop the tv band by itself, or telephone bands by themselves, or the tv band and a group of telephone channels together, depending on operational requirements.

Remote powering and monitoring

The repeater stations along coaxial cable routes are spaced relatively close together. As the provision of local power supply systems would increase the cost considerably, it is more economical to feed operating current to a large number of amplifiers by way of the communications cable. The current is in this case fed to certain more widely spaced repeater stations through filters belonging to the communications line, viz. the coaxial tube. From the feeding standpoint, a distinction is made between remote-powering repeater stations and remote-powered repeater stations; the line section between two remote-powering stations is termed the power range.

In the 12-mc system, some 24 repeaters within a power range can be remote-powered. Each remote-powering station feeds stations up to the middle of the power range on the right and the left. The remote-powering stations are spaced about 115 km apart, which is also the distance at which, as already explained in connection with equalization problems, mop-up equalization and regulation has to be performed. Thus remote-powering repeater stations are usually also fully regulated repeater stations.

The repeater equipment is so reliable in operation that preventive maintenance such as tube checking is necessary only at long intervals. The remote-powered repeater stations are for this reason usually installed in small unattended houses or in what are termed "manholes". As maintenance personnel are generally assigned to the remote-powering stations, a monitoring section will in most cases also be identical with the power range.

All repeater stations are equipped with remote-monitoring devices which automatically report trouble to the remote-powering stations and, at the same time, indicate its location and nature. It is common practice to transmit the monitoring signals over the balanced interstice pairs of the coaxial cable. Any of various remote-monitoring systems may be chosen according to customer requirements and the number of lines available. Siemens & Halske have developed a series of such devices. If demanded by organizational considerations, a remote-powering station can naturally also be operated unattended and remote-monitored. Each repeater station is additionally provided with order-wire equipment for the use of maintenance personnel in charge of telephone equipment. Such service calls are likewise transmitted over balanced interstice pairs of the cable.

The repeaters of the 12-mc system are remote-powered by the same type of a-c parallel feeding that has given good service in earlier systems. Low line losses are here secured because the voltage can be stepped up again and again at the repeater stations.

The level of the voltage at the remote-powering station depends on the length of the section. For a route of 115 km it is about twice 800 v a-c, balance-to-ground. The remote-powering circuit is composed of the inner conductors of the two coaxial pairs of a transmission system. The two outer conductors are grounded and connected to the center tap of the power transformer winding.

In dimensioning the power supply equipment it was not only necessary to give consideration to h-t problems, but also to make sure that there are no means by which remote feeding might interfere with communications transmission.

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Innovations in the Determination of Efficiency by Retardation Tests

By Rudolf Fussan

Importance of demonstration of efficiency

When contracts are placed for large generating plant efficiency has always been a major factor. It is guaranteed by the manufacturer when the generator is ordered and must be demonstrated on completion of manufacture. The unit size of hydroelectric generators like that of turbo-generators has steadily increased and above a certain size it is now no longer economical or even possible to erect them on the test bed in the maker's works. The efficiency must then be demonstrated on site. The method of determining losses by means of a calibrated driving motor as commonly employed on test beds is, however, then impossible. Practicable methods are the retardation test and calorimetric methods*. A high degree of accuracy is required from both methods as the efficiency has often to be guaranteed to within 0.01%. In addition, the usual tolerance of 10% on losses is sometimes reduced to 5%.

As the tolerance is not intended to cover errors of measurement the method must be accurate to at least 1 to 2% of the losses. If this degree of accuracy and the tolerance of 5% on losses are related to the generator output, then for example with a guaranteed efficiency

* Both innovations, the digital determination of deceleration and the straight retardation method were tried out some time ago in the large-machine test department of the Dynamowerk. Retardation tests on this principle have already been carried out in two plants.

$\eta = 98.12\%$ the losses are 1.92%, tolerance 0.096% and uncertainty of measurement about 0.02 to 0.04%. It will be seen that the degree of accuracy mentioned is just admissible for the guaranteed value.

Even though the guaranteed efficiency and the errors of measurement for the turbine, which with the generator constitutes the generating set, are less precise by at least one order of magnitude, the keen competition amongst generator suppliers compels them to quote such exact figures. This again calls for accurate measurement.

As the manufacturer is under obligation to prove the efficiency, it is primarily his responsibility to increase the accuracy of measurement by further development and refinement of test methods. In this article after some general considerations on the retardation method two innovations will be described, these being

a) a very accurate, direct determination of the retardation using an electronic pulse counter,

b) a modification of the combined input and retardation method (VDE 0530 § 58 para. 1 and 3) to obtain a "straight retardation method" which obviates the measurement of losses by wattmeter when motoring*.

Finally the applicability and practicability of the method and the amount of measuring equipment are subjected to critical examination and comparisons are made with calorimetric methods.

The retardation method

The determination of losses by the retardation method is based on the fact that when the driving motor has been switched off the machine on test is steadily braked by its losses. The deceleration for a given flywheel effect and speed is thus a direct measure of the losses.

In practice, the speed is recorded as a function of time and the deceleration determined by drawing tangents (Fig. 1).

To obtain the constant for converting the decelerations into losses, in which the flywheel effect is an unknown quantity, the input to the machine on test while motoring is determined by wattmeter. As the current-dependent losses in the stator winding are negligibly small, the input corresponds to the sum of the friction and iron losses. If these losses are compared with the deceleration derived from a retardation test at the same machine voltage, the desired conversion factor, or the flywheel effect, is obtained. With this method the inaccuracy of measurement, which is mainly attributable to the tangent construction, is about 2%.

* See footnote on page 301

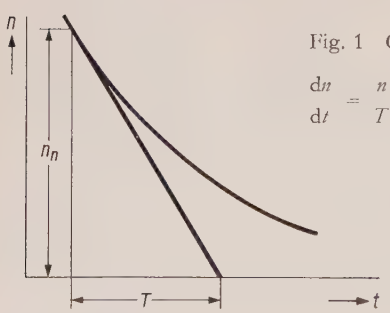


Fig. 1 Construction of tangent

$$\frac{dn}{dt} = \frac{n}{T}$$

Speed measurement

The speed is generally determined by measurement of a voltage proportional to the speed of one of the auxiliary machines mounted on the generator shaft (main exciter, pilot exciter, main-shaft-mounted generator, pendulum generator). Whether the remanence of these auxiliary machines is considered adequate or a small amount of excitation supplied from an external source is utilized will be decided in each case individually. With d.c. exciters, which are not designed for measurement purposes, the brush contact resistance, amongst other things, presents difficulties. With all auxiliary machines a certain amount of experience in electrical measurements is necessary to obtain a reproducible voltage with good speed-proportionality.

If it is desired to do without a direct frequency measurement with an instrument of high accuracy, the following arrangement for determining the speed is satisfactory: a small measuring motor-generator consisting of a synchronous motor and a high-precision d.c. tacho-generator is connected to the pendulum generator, which is always provided with modern machines. The d.c. voltage measured with a moving-coil instrument is then very accurately proportional to the speed.

A further improvement is made by suppressing the zero point of the d.c. voltage (e.g. by a simple Zener diode), the important range of 95 to 105% of the rated speed being extended over a large part of the instrument scale. Accuracy of reading can thus be considerably increased.

Wattmetric measurement of losses

The measurement of losses carried out by the conventional wattmeter method when the machine is motoring requires precision current transformers of low ratio and thus an extension of the test circuit. The power for driving the machine during this test may be drawn from the main supply system or from a second set. As, however, even the smallest fluctuations of the system frequency are sufficient to cause heavy power swings on the machine being tested, it is preferable to use a second set, which is usually available. Then the performance of the turbine governor of this set determines the magnitude of the power swings. With modern governors these fluctuations are very small. To increase the accuracy the power is measured over a certain time by means of a three-phase stop meter and is compared with the average of a number of wattmeter readings.

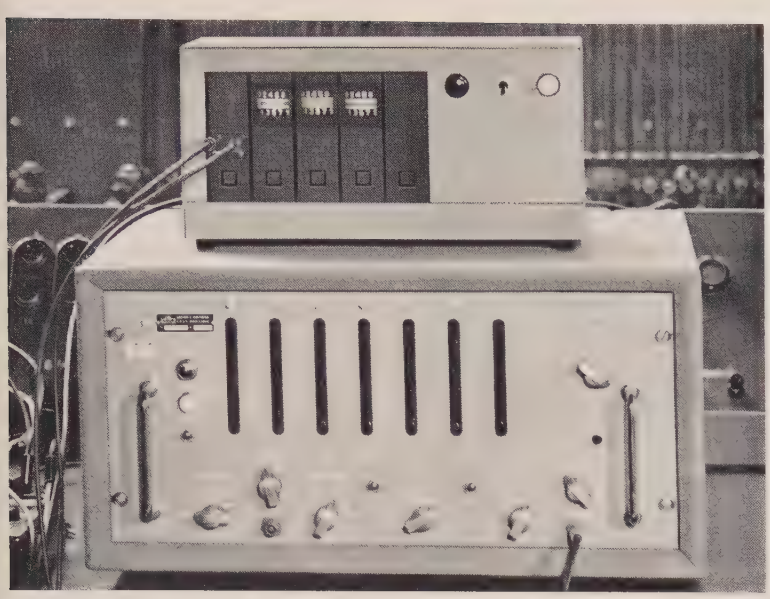


Fig. 2 Combined electronic counting apparatus

Determination of the retardation

An almost ideal method of measuring speed or retardation presented itself with the advent of electronic pulse counters. Since the speed and also the time interval between two speed measurements can now be determined with great accuracy, the retardation is obtained directly and objectively without the troublesome tangent construction.

By suitable additions to a commercial counter (Fig. 2) the following method was developed (Fig. 3):

The length of a cycle of the generator voltage* or current derived through instrument transformers is read off or printed as a numerical value after the elapse of a definite number of cycles. From a short calculation using a table of reciprocal-values ($n \sim f = 1/T$) the retardation is obtained (error $< 0.1\%$). Theoretically from the two basic equations for the loss determination

$$M = 973 \frac{P_v}{n} \qquad (1) \qquad \text{and} \quad M = \frac{\mathrm{d}\omega}{\mathrm{d}t} J \qquad (2)$$

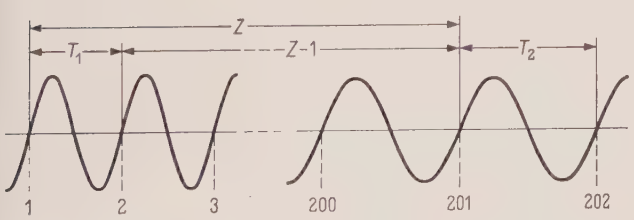


Fig. 3 Counting method for determination of $\frac{\Delta n}{\Delta t}$

the following equation may be derived

$$P_v = \frac{60 \times 2\pi f GD^2}{973 \times 4g p^2} \frac{\mathrm{d}f}{\mathrm{d}t} \qquad (3)$$

since $$\omega = \frac{1}{p} \times 2\pi f \qquad (4)$$

The first term in equation (3) contains as machine constant c the flywheel effect of the rotating masses; the second represents the drop in frequency per unit of time or the retardation (related to frequency) and will be indicated by v_f. Multiplying v_f by $2\pi/p$ gives the mechanical retardation

$$\varepsilon = v_f \frac{2\pi}{p} \qquad (5)$$

If the frequency change Δf or the time interval investigated Δt is kept very small, we can write:

$$\frac{\Delta f}{\Delta t} = \frac{\mathrm{d}f}{\mathrm{d}t} = v_f$$

As during retardation the increasing wavelength T is inversely proportional to the machine voltage, the following equation is derived from measurement of the two cycle lengths T_1 and T_2, between which there is a known number of cycles:

$$v_f = \frac{\Delta f}{\Delta t} = \frac{f_1 - f_2}{\Delta t} = \frac{\frac{1}{T_1} - \frac{1}{T_2}}{Z \frac{T_1 + T_2}{2}} \qquad (6)$$

We can then write: $P_v = c\, v_f$ (7)

in which for 50-c/s machines

$$c = 0.4935 \frac{GD^2}{p^2}$$

where:

M	Torque in m-kg
P_v	Power loss in kW
n	Speed in r.p.m.
J	Moment of inertia in kg-m-s^2
GD^2	Flywheel effect of the rotating masses in kg-m^2 (referred to the diameter)
ω	Angular velocity in s^{-1}
ε	Retardation, mechanical, in s^{-2}
T	Length of cycle in secs
p	Number of pairs of poles
Z	1 + number of cycles between T_1 and T_2
f	Frequency in s^{-1}
v_f	Retardation (related to the frequency) in s^{-2}

When a counter with six decades is used the difference in speed derived from the two measurements T_1 and T_2

* The alternating voltage of an auxiliary machine may also be employed, e.g. that of the pendulum generator.

is a few tenths of one percent of rated speed. The secant $\Delta f/\Delta t$ obtained by measurement, or $\Delta n/\Delta t$ of the curve $n = f(t)$ is practically equal to the tangent dn/dt.

It can be shown that even when the losses are most dependent on the speed ($P_v \sim n^3$) this error together with the other errors inherent in the method, which will not be discussed in detail here, and the maximum measurement error of the apparatus used result in a possible total error for the retardation of less than 0.1%.

The "straight retardation method"

Because of the high accuracy of the determination of the retardation it is often possible to dispense with the troublesome wattmetric measurement of the losses used with the input method for the determination of the machine constant c or of the flywheel effect. By loading the exciter with an external resistance during retardation the flywheel effect can be determined from the additional braking losses P_{zus} and the difference in the retardation as compared with the retardation with the exciter unloaded.

Then with

$$c = \frac{P_v + P_{zus}}{v_{f_I}} = \frac{P_v}{v_{f_{II}}} \qquad (9)$$

we get

$$c = \frac{P_{zus}}{v_{f_I} - v_{f_{II}}} = 0.4935 \frac{GD^2}{p^2} \qquad (10)$$

The accuracy of the loss measurement by means of the d.c. exciter is equivalent to that with a calibrated d.c. driving motor; it is, in fact, rather more accurate since the slight voltage fluctuations of the d.c. system, which cause current fluctuations in the driving motor, are eliminated because of the steadiness of the retardation.

Practical application of the method

The following example, which illustrates the practical application of an electronic counter for measuring the deceleration and determining the losses and flywheel effect, will facilitate understanding of the two previous sections. The test was carried out on a horizontal, three-phase, synchronous machine with a rigidly coupled exciter.

Data of the synchronous machine: 11 kV, 1,575 A, 30 MVA, 1,000 r.p.m., 50 c/s.

Data of the exciter: 200/300 V, 600/900 A, 120/270 kW, contin. duty/10 secs, 1,000 r.p.m.

A retardation test was first made with the main generator unexcited: the exciter was loaded with a resistor, delivering 83.0 kW at rated speed and a terminal voltage of 258 V. During retardation the counter indicated the following lengths of the cycle at intervals of 200 cycles:

$T_1 = 19{,}850.7\ \mu s$
$T_2 = 20{,}022.9\ \mu s$
$T_3 = 20{,}197.6\ \mu s$

The retardation v_{f_I} is derived according to equation (6) as follows:

$T_1 + T_2 = 39{,}873.6\ \mu s$ $\qquad$ $T_2 + T_3 = 40{,}220.5\ \mu s$

$\frac{1}{T_1} = f_1 = 50.3758$ c/s

$\frac{1}{T_2} = f_2 = 49.9424$ c/s $\qquad$ $\frac{1}{T_3} = f_3 = 49.5108$ c/s

$f_1 - f_2 = 0.4334$ c/s $\qquad$ $f_2 - f_3 = 0.4316$ c/s

$v_{f_1} = \frac{2}{200} \frac{f_1 - f_2}{T_1 + T_2} = 0.10869\ s^{-2}$ $\qquad$ $v_{f_2} = 0.10731\ s^{-2}$

The value of v_f relates in each case to the mean of the two frequencies f_1 and f_2. For 50-c/s machines this mean value, in terms of speed, is the sum of the two frequencies in c/s, i.e.

$$\frac{f_1 + f_2}{2} = f_{12} \text{ or } f_1 \text{ in c/s} + f_2 \text{ in c/s} = n_{12} \text{ in \%},$$

in this example $n_{12} = 100.3182\ \%\ n_n$

$n_{23} = 99.4532\ \%\ n_n$

Interpolation* gives, for $n = n_n$, the retardation

$v_{f_1} = 0.10818\ s^{-2}$

A second retardation test was then made again with the main generator unexcited but with the exciter at no-load. To eliminate the iron losses of the exciter from the calculation of the additional braking losses in accordance with equation (10) the unloaded exciter was excited to 258 V.

The counter gave the following cycle lengths at intervals of 400 cycles:

$T_1 = 19{,}862.6\ \mu s$
$T_2 = 20{,}054.5\ \mu s$
$T_3 = 20{,}248.7\ \mu s$

Then:

$T_1 + T_2 = 39{,}917.1\ \mu s$ $\qquad$ $T_2 + T_3 = 40{,}303.2\ \mu s$

$f_1 = 50.3456$ c/s

$f_2 = 49.8642$ c/s $\qquad$ $f_3 = 49.3858$ c/s

$f_1 - f_2 = 0.4814$ c/s $\qquad$ $f_2 - f_3 = 0.4784$ c/s

$v_{f_1} = \frac{2}{400} \frac{f_1 - f_2}{T_1 + T_2} = 0.06030\ s^{-2}$ $\qquad$ $v_{f_2} = 0.05935\ s^{-2}$

v_{f_1} relates to $n = 100.2098\ \%\ n_n$, $\qquad$ v_{f_2} to $n = 99.2500\ \%\ n_n$

Interpolating to rated speed,

$v_{f_{II}} = 0.06010\ s^{-2}$

* The error due to interpolation is very small and was included when determining the inherent error of the method.

The difference retardation $v_{f\,\mathrm{I}} - v_{f\,\mathrm{II}} = 0.04808\ \mathrm{s}^{-2}$ according to equation (10) is due to the additional braking losses P_{zus}. This is made up of the following components:

a) Power output at terminals	$UI = 83.0$ kW
b) I^2R losses in the main current winding at 40 °C ($r_{20} = 16.86$ mΩ)	$I^2 r_{40} = 1.89$ kW
c) Additional losses $(I/I_n)^2 \times 0.01\ N_n$	$= 0.33$ kW
d) Brush contact losses	$2I = 0.64$ kW
Additional braking losses	$P_{\mathrm{zus}} = 85.86$ kW

According to equation (10) we now get the conversion constant

$$c = \frac{P_{\mathrm{zus}}}{v_{f\,\mathrm{I}} - v_{f\,\mathrm{II}}} = \frac{85.86}{0.04808} = 1{,}780$$

and the flywheel effect of the rotating masses of the set

$$GD^2 = \frac{c\,p^2}{0.4935} = \frac{1{,}780.9}{0.4935} \quad 32{,}500\ \mathrm{kg\text{-}m^2}$$

In the manner described in accordance with equation (7) and by determining the retardation v_f the friction losses of the set (without the iron losses in the exciter), the iron losses and the stray-load losses of the main generator on short circuit are evaluated. Finally the efficiency is calculated from the segregated losses in the usual way.

Critical assessment

Comparing the "straight retardation method" with the conventional "input and retardation method" the former is not only more accurate and convenient but involves a simpler measuring circuit with less measuring and auxiliary apparatus. In cases where the turbine can be run dewatered at rated speed, the driving power being supplied by the electrically coupled second unit, it would in fact be possible to dispense with the two separate exciter sets, which are otherwise necessary in the case of machines with rigidly coupled exciter for running up to full frequency and for keeping the excitation constant during the retardation. When using the rigidly coupled exciter to excite the generator the dependence on speed of the losses to be measured is in fact increased by one power, causing sharper bending of the curve $n = f(t)$, but the accuracy of the method described is not significantly reduced.

An inherent disadvantage of the retardation method is that the windage losses of the turbine runner and the friction losses of a bearing not forming part of the contract for the generator are included in the total measured friction losses. Frequently, calculated values for these losses given by the turbine supplier are subtracted when determining the efficiency, although this is an unsatisfactory method. To eliminate the turbine losses, the turbine is in some cases uncoupled. In other cases the error due to the unreliable calculated value is tolerable if the turbine losses represent only a small proportion of the total friction loss, e.g. if with Kaplan runners and Pelton wheels only the windage loss has to be subtracted, all other losses being attributable to the generator. In cases of doubt and whenever the error would be excessive the friction losses which devolve on the generator supplier should be measured calorimetrically.

Against this disadvantage of the retardation method is set the advantage that the individual readings are obtained quickly. The recording of a series of readings to determine the iron losses as a function of the flux density also presents no difficulty. Verification of the guaranteed flywheel effect of the rotating masses is possible only by the retardation method.

A decision must be made in each case as to which of the two methods, retardation or calorimetric, shall be used to demonstrate the efficiency or whether a combination of the two is preferable. Apart from considerations of the method of measuring, account must be taken of the kind of turbine, the difficulty of dewatering the turbine, the method of cooling the generator or the cooling medium and other factors depending on local conditions.

Traffic and Quality-of-Service Observation in Dial Offices

By Paul Gonschior and Franz Schwub

It is the objective of all telephone administrations to provide switching equipment and networks that furnish their subscribers with service that is as free of operating faults and traffic congestion (lost calls, delays) as possible. Traffic and quality-of-service observations provide an objective picture of whether subscribers receive the desired standard of service on successful calls – hence whether the switching equipment is economically used – and whether their calls meet the qualitative requirements.

Measurements show whether additional switching devices or new inter-office trunks should be provided and also whether preventive maintenance should be improved in general or only at certain points. The accu-

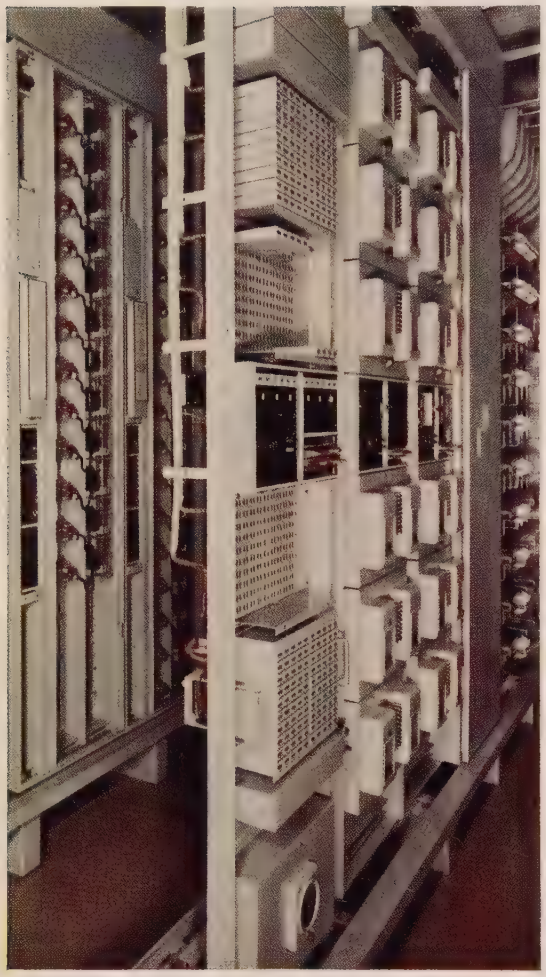


Fig. 1 Traffic measuring equipment with 24 erlangmeters, ATB meters and congestion time meters

mulated statistics yield information that is valuable for future development, as also a knowledge of the time intervals between switching signals during the establishment and clearing of calls.

Traffic and quality-of-service observation thus aids rationalization in the processing of telephone traffic and it is naturally desirable that it be carried out with as few skilled personnel and as little material outlay as possible. For this reason central evaluation points are established which, operating to a large extent automatically, determine the load carried by a dial office, record the traffic intensities, and communicate the latter information to the computers of a data-processing system for further analysis by means of punched-card equipment.

The most favorable observation period is the peak traffic period. Measurements can in normal circumstances be restricted to random sampling.

Traffic measurement

The traffic intensity at the various switching stages of a dial office is determined with the aid of the traffic measuring equipment (Fig. 1). The unit of traffic intensity is the erlang, which represents 1 traffic unit per observation hour. The traffic measuring equipment interoperates with a central evaluation point. The trunkgroups to be measured are connected to the erlangmeters by way of a group-selecting relay repeater. The values measured by the erlangmeters are automatically recorded. The measurements can in this way be continuously checked (Fig. 2).

For the transmission of measured values, the erlangmeters are provided with a contact that emits a pulse every time a certain traffic level is reached. The pulses of several erlangmeters are transmitted over a single channel, which is the same one as previously used for the group-selecting process. A pageprinter at the central evaluation point records the 15-min sums of the pulses, along with appropriate details such as the date and clock time. The continuously arriving measured values can here be checked and, if necessary, analyzed. The growing mass of collected data will ultimately necessitate the further automation of data processing. Measuring results can be analyzed, for instance, with the aid of perforated tape equipment and electronic computers such as the Siemens 2002 data-processing system.

It is in this way possible to routine a dial office at intervals of, say, one year. An interim picture of the efficiency

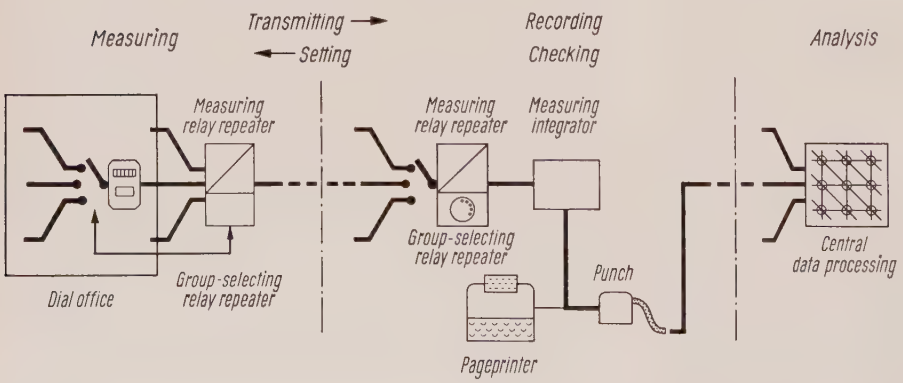


Fig. 2 Traffic measuring routine extending from connection of measuring equipment to specimen in dial office to analysis of the measuring results by a central data processing system

of the network can be obtained by cutting in congestion time and ATB meters. These show the recurrence rate with which all accessible connecting paths are occupied. Meter readings taken at long intervals are sufficient to determine whether the admissible limits are observed or exceeded. In some cases unscheduled traffic intensity measurements may be necessary.

In dial offices, the traffic measuring equipment described is usually accommodated in frames. In small unattended dial offices recourse is taken to erlangmeters and measuring relay repeaters designed as portable cases. These plug into special access shelves with only a few hand motions. Traffic measuring equipment is also essential for large PABX's so as to insure that long-distance calls in particular are able to get through to PABX extensions without meeting congestion.

Destination factor and traffic flow measurements

In direct distance dialing it is frequently important to obtain information on the traffic between two certain junctions in order to judge whether new trunkgroups should be installed or which of the existing trunkgroups should be enlarged.

Destination factor and traffic flow measuring equipment here analyzes dialed information to determine the composition of the traffic according to call destinations. The equipment (Fig. 3) determines, for example, the recurrence rate with which a certain code number occurs among a mass of code numbers. The ratio between the two values is defined as the destination factor. If the overall outgoing traffic measurable with erlangmeters is known and multiplied by the destination factor, the result represents the approximate share of the traffic flowing to the destination office.

With the aid of an accessory of the destination factor and traffic flow measuring equipment it is possible to determine the sum of holding times of each route and so to calculate the average holding time. If measurements are continued until the sum of the holding times of all routes corresponds to the traffic intensity of the offering trunkgroup during the busy hour, it is possible, with due allowance made for the factors involved in random sampling, to read the proportional amount of traffic per route directly from the measuring equipment. The same accessory can also be used to determine pure conversation time. This will be of value in cases where certain measures are related to tariff questions.

Further accessories of the destination factor and traffic flow measuring equipment are used, either together or assigned according to routes, to determine the time intervals occurring during the establishment and clearing of calls. These include, for example, interdigit pauses and answering delays, as well as busy tone, end-of-selection and answer signals. These intervals are related to the progress in establishing a call. Such knowledge is of importance in that it may determine the holding time of control devices, which means that the switching speed of the latter must be adapted accordingly. The same equipment also determines the percentage of calls that fail to find a circuit to the terminals of a hundred-group of subscribers.

Quality-of-service measurements

The quality-of-service measuring setup serves for observing the interoperation of all the switching devices within an entire dial office (Fig. 4). It connects to various switching devices by way of the main distribution frame; subscriber lines and telephones can be included in the measurements.

The entries in trouble sheets are frequently regarded as a measure of the quality of a dial office. The faults entered over a certain period are added together and compared with the quantity of connected subscribers: faults per 100 line units. This information, however, does not consider either the quantity of calls, the size of the dial office, or even the effect of faults upon operation, and is therefore little suited to objective comparisons. In order to obtain statistics allowing a comparison of dial offices, the NTG Communications Association has specified quality

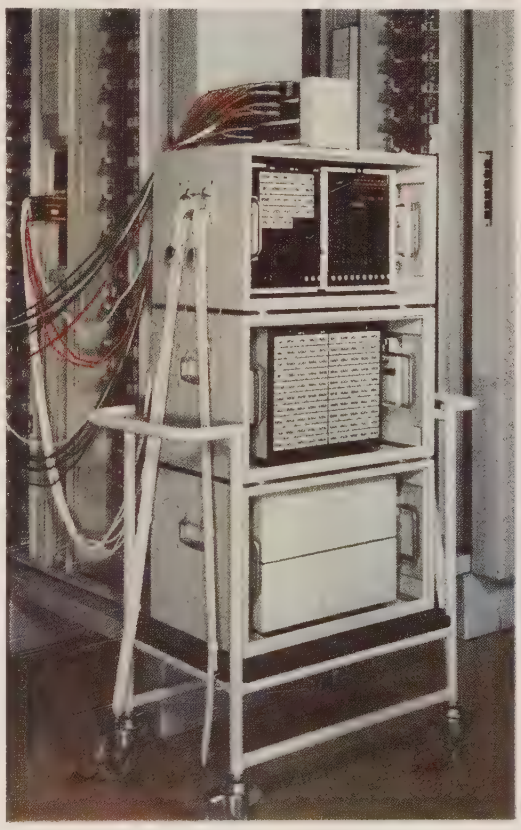


Fig. 3 Destination factor and traffic flow measuring equipment with indication and control panel, meter panel, adapter and destination factor relay set (from top to bottom)

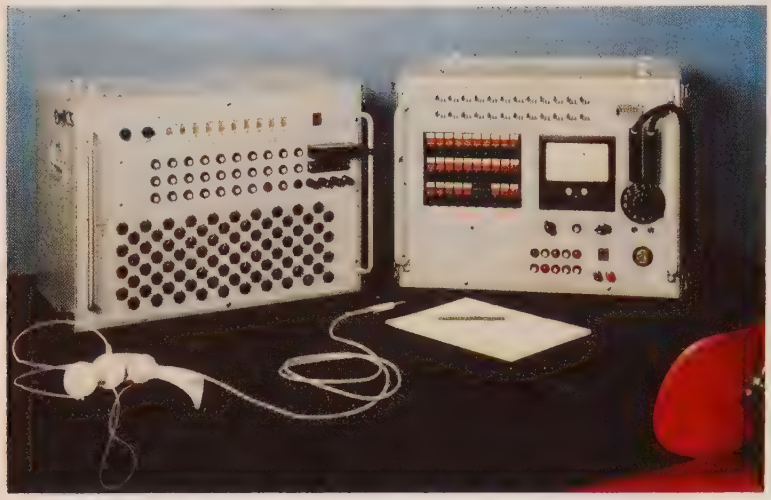


Fig. 4 Quality-of-service measuring setup, measuring case of automatic dialing (left) and program control (right)

such as defective wiring, high attenuation or noise voltage in the transmission path, false metering or absence of metering, are detectible only within a connecting path. All faults are registered by respective meters according to their category, as is also the quantity of artificial calls.

Quality-of-service observations also extend to the observation of progress in the establishment of calls. The setup is best connected at the point where the calls originate. To obtain a sufficiently broad average it may be desired, for instance, to observe at least 50 subscriber line circuits. If the setup is connected to the 1st group selector stage, 20 inputs will be sufficient. Dialed long-distance calls are observed at appropriate switching devices. Such measurements can be performed at a central point for several dial offices in common.

coefficients and formulas for the appraisal of dial offices. The quality of service can be exactly determined with the aid of a quality-of-service measuring setup, which automatically generates artificial traffic and carries out quality-of-service observations.

To insure that the measuring runs yield results with a sufficiently great confidence coefficient, the setup is connected to various points of a dial office and as many artificial calls as possible are generated. Measurements are performed automatically at high speed. The setup can also be used for fault location. Some of the faults discovered, Perforated tape equipment or punched-card machines have given good service in the analysis of measuring results. Meters may be installed to furnish direct readings of the recurrence rate of certain faults; they also serve for the calculation of congestion and fault coefficients.

Quality-of-service measuring equipment in this way makes it possible to check the effectiveness of maintenance work, to control the use of measuring and test devices, to intercompare various dial offices with respect to their quality of service, and to locate faults.

Programmed Digital Control for Test Stands in the Motor-car Industry

BY WERNER LEONHARD AND SIEGFRIED WALLER

Automatic control equipment and electronic measuring apparatus make possible a considerable degree of rationalisation of the work on development test beds in the motor-car industry. Operation is simplified and test results can be obtained more quickly and with greater certainty. In addition, simulated road tests are being used to an increasing extent[1].

An engine can, of course, be tested by installing it in a vehicle, which is then driven over mountain roads, high-speed motorways and in city traffic. Such a test will provide useful information as regards wear of the engine and fuel and oil consumption under actual road conditions. The method has, however, the disadvantage that the result is affected by uncontrollable circumstances such as weather, condition of the road surface, density of traffic and the actions of the driver. No precise conclusions can therefore be drawn from a comparison of two test runs. The tendency is therefore to transfer such testing to the test stand. This presupposes that the conditions of a road test can be simulated with sufficient accuracy while maintaining the time relationships of the essential working variables. For the internal combustion engine these are: the speed, the torque or the depression in the intake manifold and the temperatures of oil and water; for the gear box and rear-axle gearing or for torque-converters it is the speed, the torque

1 Waller, S.: Automation applied to the Experimental Test Beds in the Automobile Industry. Siemens Review XXVI (1959) pp. 169 to 174

transmitted and the oil temperature; and for the brakes it is the speed, the braking torque and the temperature of the brake drum.

The new programmed digital control unit built up with transistorized Simatic* components enables the time relationships of the relevant operating variables to be accurately reproduced in the laboratory according to predetermined or experimental programmes.

Programmed control

The reference values for the operating variables can be fed to the control unit stepwise or continuously. The time function and accuracy of the reference value characteristic determine the choice of the storage medium.

For a stepwise change of one or, simultaneously, several controlled variables punched tape as used in teleprinter techniques is suitable. The information for each programme step, i.e. the desired values for the operating variables and the duration of the step, are represented by a block of digital characters. Each desired value is represented by an address and a numerical value. For each step only the particular quantities to be changed have to be programmed. The transport signal for the tape reader is given automatically either after expiry of the time prescribed for the programme step or after a prescribed test condition has been reached. The digits of a block of information arriving in sequence from the tape reader are transmitted to the appropriate reference-value memory while the previously stored value is erased.

With a punched tape as storage medium in conjunction with digital control an absolute long-time accuracy of less than 10^{-3} is obtained. The variables must be measurable on the test bed with a high degree of accuracy, as is the case with speed or torque measured by using a torque balance. Punched tape can therefore be used with advantage wherever importance is attached to the digital presentation of the controlled conditions and exact reproducibility, as for example for long-time comparison measurements.

Continuously changing reference values require a storage medium with a very short access time, so that a rapid sequence of desired values can be obtained. This requirement is fulfilled by the magnetic tape owing to its high storage density in several parallel channels and the practically continuous flow of information. During a road test the various measured values are written and stored on the tape, providing a complete record of their dynamic relationships. It should, however, be noted that momentary peaks of speed or torque are somewhat levelled owing to the great differences in the rotating masses in the vehicle and on the test bed and also to the inertia of the automatic control circuits.

To enable a simple, robust and light magnetic-tape equipment to be used, the amplifiers of which need not satisfy any special requirements as to linearity and phase-accuracy, a pulse-recording system was selected, for which the transmitter signals are converted into proportional pulse frequencies.

The accuracy of programmed control depends on the detection and frequency conversion of the measured quantities and also on the differences in tape velocity during recording and play-back. With simple conversion equipment and portable recorders this is of the order of a few percent. Programming with magnetic tape is therefore always to be considered when the emphasis is not so much on accuracy but on realistic simulation of an actual road test.

* Trade-mark

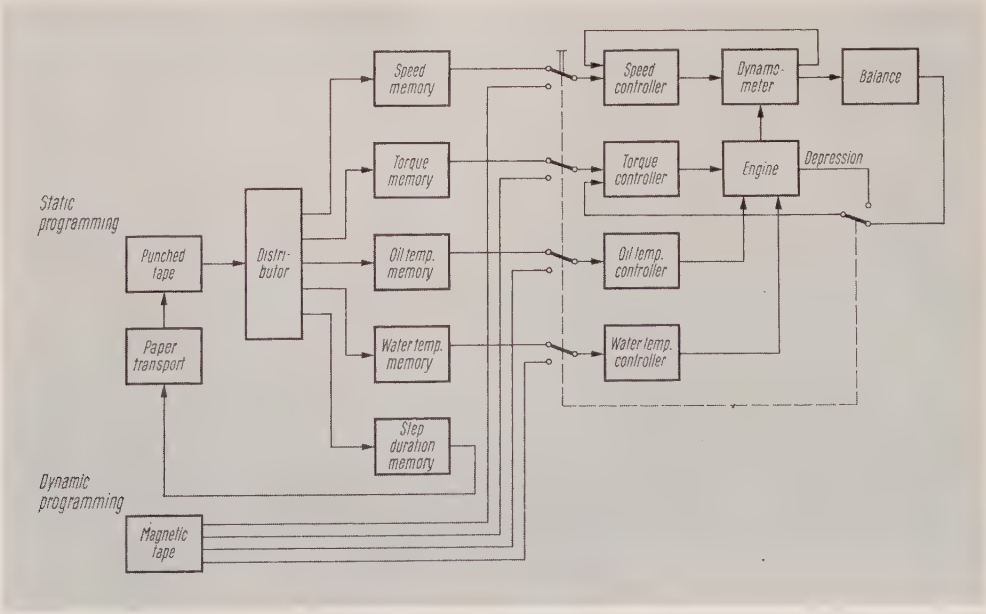


Fig. 1 Programmed digital control system for a dynamometer test stand

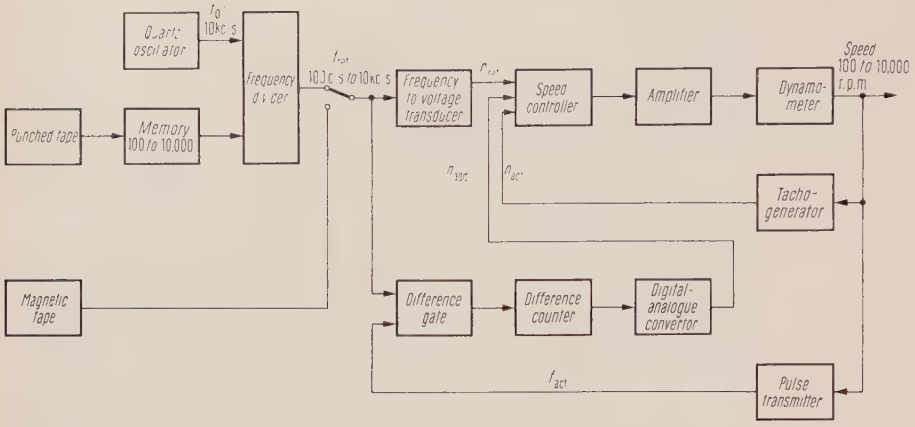


Fig. 2 Programmed digital control for a dynamometer test stand (speed channel)

Fig. 1 shows the four control loops of an engine test bed for automatic control of speed, torque, water and oil temperature. For static programming the desired values are taken as blocks of information from the punched-tape reader and fed to the control circuits via transistorized memory circuits. With dynamic programming the control circuits are fed directly from the magnetic tape.

The programme control unit

Fig. 2 shows the block diagram of the speed channel. With static programming the desired decimally coded reference number is stored into the speed memory. The range of the speed reference is 10,000, one unit corresponding to one revolution per minute. Following work by C.I. JONES of Westinghouse Electric Corp. the desired number is converted in a quartz-controlled frequency divider on a numerical basis into a reference pulse train, which acts as the desired frequency f_{ref} for the automatic speed controller. If the quartz reference frequency $f_0 = 10$ kc/s and the desired number is 7,823, corresponding to 7,823 r.p.m., the frequency divider delivers 7,823 pulses per second.

The frequency divider includes a four-place decimal counter serving as a "clock" which is operated continuously in one direction by the reference frequency f_0; the four decades count with the frequencies 1,000, 100, 10 and 1 c/s. On each counting period the number of pulses corresponding to the associated digit of the desired number are drawn from each decade. Suitable provisions for synchronizing the pulses ensure that all the pulses are not coincident and can be combined additively to form the common pulse train.

As the reference pulses arise due to the suppression of individual cycles of the reference frequency, equidistant pulse trains only result from a few definite reference numbers. In all other cases periodic pulse groups occur, the recurrence period of which depends on the reference frequency and the desired number. The degree of cyclic irregularity can be kept small by suitable design of the divider circuit. In the worst case, for example, an odd digit in the fourth place of the desired number leads to an irregularity in the reference pulse train of about 0.01% of the maximum frequency, i.e. to a fluctuation of the desired speed of about 0.01% with a frequency of 1 c/s. The pulse trains derived from the higher decades of the divider, considered individually, exhibit a correspondingly higher frequency of the periodic disturbance. Their effect on the automatic control can therefore be neglected.

For dynamic programming with a continuously variable signal the reference pulse train is derived not from the frequency divider but directly from the magnetic tape.

The reference pulse train is first fed to a frequency-to-voltage transducer where it is converted into a proportional voltage, which acts as desired value for a normal analogue speed control loop. This has the advantage of high dynamic quality, while requiring little equipment. The transducer consists of a pulse-forming stage, which generates a unit pulse of definite voltage-time area for each reference pulse, as well as a circuit for averaging the pulse train produced. The conversion is accurate to within about $\pm 2\%$. Additional accuracy is obtained through the use of a digital speed loop.

The reference pulse train derived from the frequency divider or from the magnetic tape is also compared in a difference gate with the actual frequency derived from the a.c. tacho-generator or a pulse-generating disc. Positive and negative difference pulses are derived from the uncorrelated desired and actual-value pulse trains and are fed to a difference counter. Its count is evaluated and fed through a digital-to-analogue converter in the form of a small supplementary desired value to the analogue speed controller. The supplementary digital controller thus behaves like an integral-type speed regulator.

The digital controller as a supplementary unit to the analogue controller has the following important advantages over a straight digital controller:

1. As the digital controller has only to correct comparatively slow deviations, a lower pulse frequency (maximum about 10 kc/s) can be employed. This allows the use of narrow-band signal wiring with less liability to pick up stray signals.
2. The amount of equipment needed is less, as the function of the apparatus is simpler and the range of operation

of the digital controller has only to cover the range of error of the analogue controller.

3. Should the digital controller be out of order emergency analogue operation can be maintained.

Compared with sampling-type digital controllers using a comparable pulse frequency, the continuous-type digital controller has the advantage of higher dynamic quality as there is no dead time.

The torque channel functions in a way similar to the speed channel. With static programming the desired number, here with a maximum of ±1,200 units, is transferred from the punched tape into a transistorized torque reference memory. The torque is measured by means of the inclination balance of a cradle dynamometer. The position of the pointer spindle is photoelectrically detected with a slotted disc. The incremental pulses are fed with correct sign to an actual-value counter. The integral of the torque deviation is derived from the numerical values of the torque reference memory and the actual-value counter and fed as a corrective signal to the quick-acting analogue torque control loop. This receives its desired value through a digital-to-analogue converter also from the torque reference memory. The actual value for the analogue torque control loop is taken from a substitute quantity, e.g. the intake manifold depression of a petrol engine, because the dynamometer inclination balance is unsuitable for dynamic measurement because of its slow transient response.

With dynamic programming using magnetic tape the substitute quantity for the torque is recorded during the test run. In the laboratory it is played back and used as a reference signal. As alternatives to the measurement of depression the direct measurement of the torque on the engine shaft or of the position of a throttle valve may be considered. In the first two cases analogue transducers with a d.c. output voltage proportional to the measured quantity may be used; the voltage can then be converted into a pulse train. When measuring the throttle valve position the measured variable may be evaluated directly as a number or frequency by means of a digital transmitter.

So as to be independent of local errors in the magnetic tape the desired values are stored on the tape as pulse-train frequencies. If the actual values for the torque substitute and the temperatures are also available in the form of pulse frequencies, then the method of digital frequency comparison may be employed as in the case of the speed control loop. Because of the reduced accuracy with dynamic programming the amount of equipment may be reduced as compared with speed control.

To detect the actual values of oil and water temperatures an analogue temperature detector is used with an accuracy of about 1% of the range. This is adequate for practical requirements. As the desired and actual values for the temperatures only change slowly even in dynamic tests time division multiplexing of the pertinent magnetic tape channel is practicable.

Indoor Isolators to New Standards (Insulation Ratings 10 to 30 kV) with Cast-resin Insulation

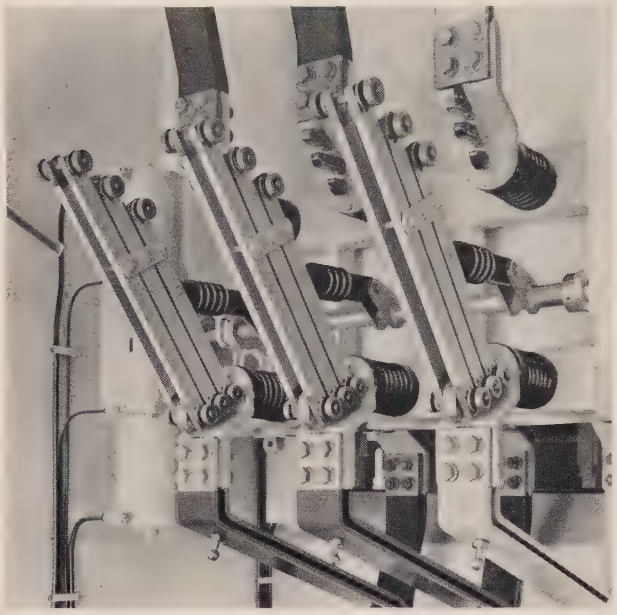
By Erwin Hartmann

Until recently, the Recommendations of the IEC (International Electrotechnical Commission) often agreed extensively with the Rules of the Association of German Electrical Engineers (VDE) and with the German Industrial Standards (DIN). However, the publication of new IEC Recommendations for the rated breaking capacities and current ratings of circuit breakers recommended ratings which are at variance both in their individual values and in their spacing with the German standards applying until now.

In order to facilitate sales abroad, the DIN Standards for high-voltage circuit breakers were brought into line with the relevant IEC Recommendations (DIN 43612). Since there is almost always an isolator connected on the line or load side of a circuit breaker, the standards applying for isolators were adapted to those for circuit breakers (DIN 43635).

Although the validity of the old DIN Standard 43617 does not cease until December 31, 1962, the Siemens-Schuckertwerke have already adapted their isolators to the new Standard DIN 43635 in the few months following its publication so that, up to an insulation rating of 30 kV, only isolators conforming to the most recent standards are supplied.

The most important changes in these new standards are the current ratings of 400, 630, 1,250, 1,600, 2,500, 4,000 and 6,300 A compared with the former ratings of 400, 600, 1,000, 2,000, 3,000, 4,000 and 6,000 A. The maximum values of the rated impulse currents (permissible peak asymmetric short-circuit current with the switch closed)



Indoor isolator with cast-resin insulation to DIN 43635, insulation rating 10 kV, rated current 2,500 A, rated impulse current 160 kA

were changed from 100 and 150 kA to 75, 125 and 160 kA. The third change concerns the rated short-time currents (r.m.s. value of the 1-sec. current). According to the new standard, these are now 40 percent of the corresponding rated impulse currents.

In all cases where the old isolator types were brought in line with these new values, it was possible to keep the former connection and mounting dimensions, a fact which is of considerable importance with regard to the interchangeability of parts, extensions and the supply of spares.

The new standard also contains isolators, however, which necessitated completely new designing, e.g. of the models for a current rating of 1,600 A. With these isolators, the design used was that of the well-proven isolator type H 246, i.e. each isolator has a moving contact which is subdivided into several parallel isolating blades with roller-type contacts; each individual parallel blade makes three-point contact; the stationary contacts are stepped and – like the moving contacts – are hard silver-plated.

The double-piston pneumatic operating mechanism has been retained which, in conjunction with the operating valve, makes possible pneumatic switch position indication and thus permits the installation of the auxiliary switch outside the high-voltage compartment. Isolators with ratings of up to 1,250 A can naturally also be manually operated by means of switch-sticks or linkage mechanisms.

This change was accompanied by the introduction of cast-resin insulation for indoor isolators for medium-high voltages. Isolators with porcelain insulators are still manufactured, but the main accent is now on isolators with ribbed insulators of cast resin. For instance, all new isolators designed to DIN 43635 – which could not be developed from already existing types and had to be completely re-designed – are available with cast-resin insulation only. The well-known advantages of ribbed insulators of cast resin are utilized to the full with the isolators since the insulating couplers are also of cast resin and are ribbed in shape. The main features to be mentioned here are the high alternating withstand voltage even with highly conductive contamination layers and the high resistance to the thermal effects of short-circuit arcs.

By using ribbed cast-resin insulators, the isolators also comply with the new VDE Specification 0111/2.61 (Directions for the coordination and testing of insulating capacity in a.c. installations of 1 kV and more), in spite of the fact that they still have the same small dimensions as before and in some cases are even smaller, although the impulse withstand voltages required by these specifications are in some cases considerably higher than the values previously permitted.

NEW EQUIPMENT

Electroacoustic and Cinematographic Equipments of the Auditorium Maximum of the Hamburg University

By Joachim Jäckel and Werner Lemke

In November 1959, four years after its construction had been started, the building accommodating the new auditorium maximum was handed over to the authorities of the Hamburg University. The detached building, designed by Professor Hermkes, contains two lecture halls (Fig. 1) with 1,200 and 600 seats, respectively, which are separated by a retractable partition wall. By lowering this wall into the basement, both halls can be combined into one. The partition wall weighs about 80 tons and is one of the largest of its type hitherto built. It also serves as a very efficient acoustic screen between both halls. During the erection of the building, Professor Cremer acted as adviser on all questions of acoustics. The Hamburg office of Siemens & Halske was entrusted with supplying and installing the electroacoustic and cinematographic equipments. In close co-operation with the architect and the acoustician, all requirements concerning the performance of these equipments were fully met. The following facilities were to be provided:

Fig. 1 The Auditorium Maximum of the Hamburg University. The part of the auditorium visible in the background can be separated from the other part by raising a motor-operated partition wall

With joined halls:

1. A public-address loudspeaker system for aiding the lecturer. The room acoustics are such that, if the lecturer has a clear pronunciation, no speech amplification is required. The acoustician therefore raised the demand that, with the public-address system in operation, the whole audience should also be under the impression of hearing the lecturer directly.
2. Equipment for showing standard films, 16-mm substandard films, and epidiascope projections. Since the architectural design of the platform did not permit the installation of a fixed screen, a roller-type screen had to be provided.
3. Facilities for recording and reproducing high-class musical performances on and from the platform, respectively.
4. An inductive hearing-aid system for both halls, permitting to be put into operation either as a whole in the joined halls, or separately in one or both of the two separated halls. Moreover, facilities were to be provided for installing a simultaneous interpreting system at a later date.

With separated halls:

1. For the larger (lower) hall, the same facilities (except the cinematographic equipment for standard film) were required as those provided for the joined halls.
2. The same facilities required when both lecture halls are joined must also be available for the smaller (upper) hall when being used separately. Since, for technical reasons, the attachment of a projection screen to the partition wall was not possible, a roller-type screen had to be provided in this case, too.

Design

The Large Hall was equipped with a combined projection and control stand, while a projection booth was installed behind the rear wall of the Small Hall. The projection stand in the Large Hall (Fig. 2) comprises a control desk whose functions are shown in the wiring diagram (Fig. 3), a record player, a tape recorder, a projector for 16-mm substandard film, and a Leitz epidiascope. Concealed inside the stand are the preamplifiers and power amplifiers for the public-address and hearing-aid systems. When the two halls are joined, the total cinematographic and acoustic equipment is controlled from the projection stand (except standard-film demonstrations). Mounted in the projection booth behind the rear wall of the Small Hall are two standard-film projectors, type Bauer B 11, a 16-mm substandard-film projector, and a Leitz epidiascope. Moreover, a Klangfilm* pre-amplifier rack, a main-amplifier rack for the sound-film equipment, an amplifier rack with control panel for the electro-acoustic equipment, as well as pre-amplifiers and power amplifiers for the public-address and inductive hearing-aid systems (Figs. 3 and 4) are installed in the projection booth.

The problem of sound radiation was so well solved that the listeners actually never have the impression that the speech or music they hear is reproduced through loudspeakers. When both halls are joined, the sound for the lower part of the Large Hall is radiated by four loudspeaker battens (Schallzeilen*) mounted in the speaker's desk of this hall. For the two galleries, two loudspeaker battens were installed right and left in a recess of the ceiling. Two further

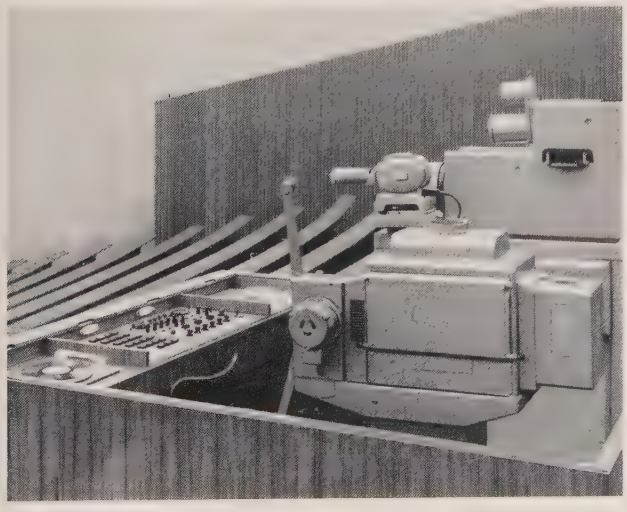


Fig. 2 Projection stand with control desk in the Large Hall

* Trade-mark

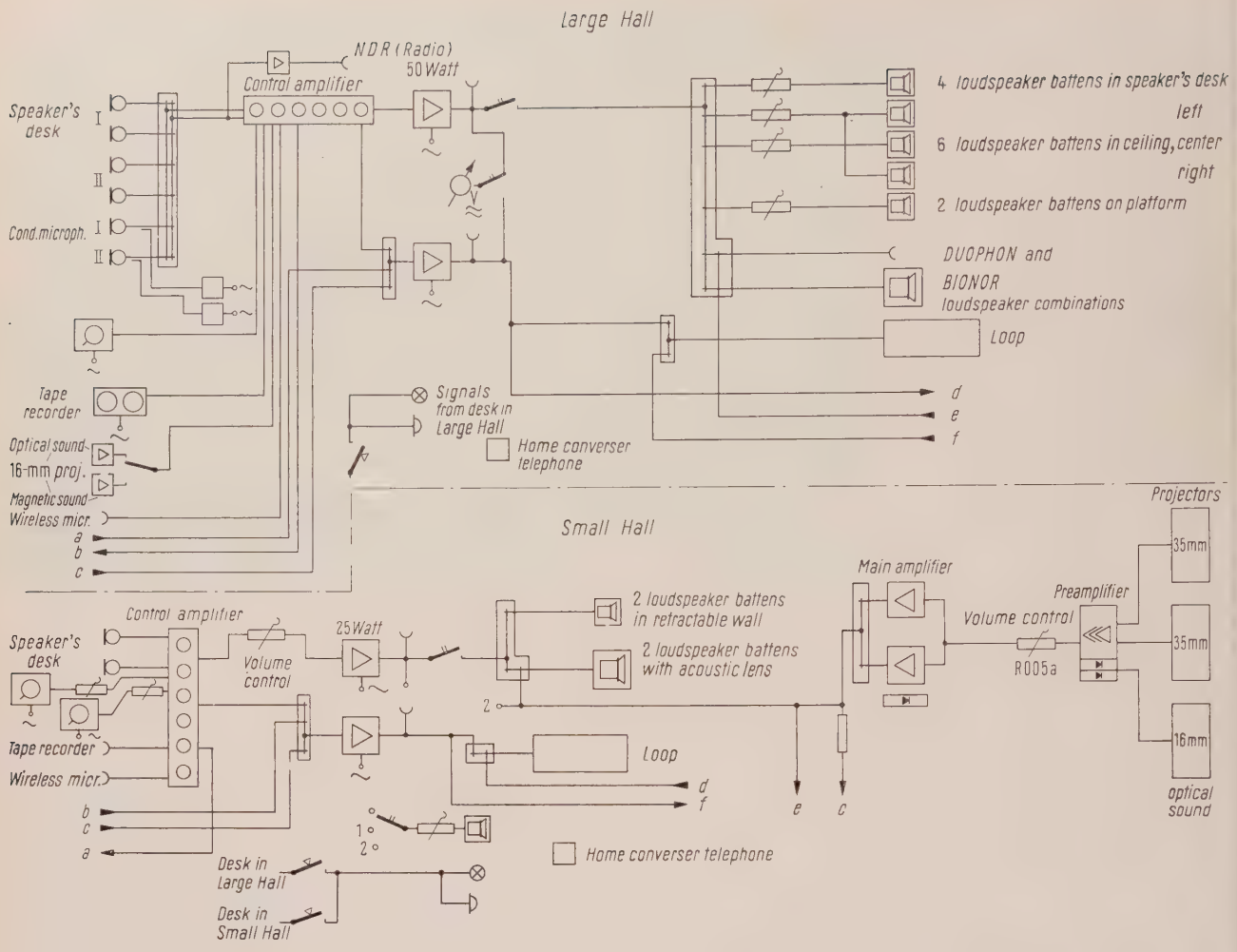


Fig. 3 Basic circuit diagram of the electroacoustic and cinematographic equipments

loudspeakers of the same type are arranged in the middle of the same recess for meeting the acoustic requirements of the Small Hall (Fig. 5). When the two halls are separated, the sound for the larger one is radiated by the equipment described above, while the acoustic equipment of the smaller hall consists of two loudspeaker battens mounted on either side of the retractable partition wall, half-way between floor and ceiling. On the same level, but in the middle of the partition wall, loudspeaker battens with "acoustic lens" are provided for cinematographic demonstrations and high-quality musical performances. Special technical problems had to be solved for meeting all requirements concerned with the projection of motion pictures. The standard-film projectors in the projection booth can be adapted to each of the two screens by exchanging their objective lenses. The sound reproduction is effected by a KLANGFILM loudspeaker combination set up on the platform behind the screen. Before starting a performance, this loudspeaker arrangement is lifted from out of the basement by means of a special hoisting device. For ensuring a perfect picture quality, Perlux projection screens (Harkness System) were chosen for both halls. Since motor-operated roller-type Perlux screens of such great dimensions had never been manufactured before, some technical difficulties had to be overcome. Each screen is wound on a reel of large diameter and kept taut by means of a counterweight fastened to its lower seam: The rolled-up screens are completely enclosed in dust-proof casings (not shown in Fig. 5). When unrolled, they measure 8.5 m × 9 m (27′11″ × 29′6″) and 6 m × 10 m (19′8″ × ×32′ 10″), respectively. The larger screen can be operated from

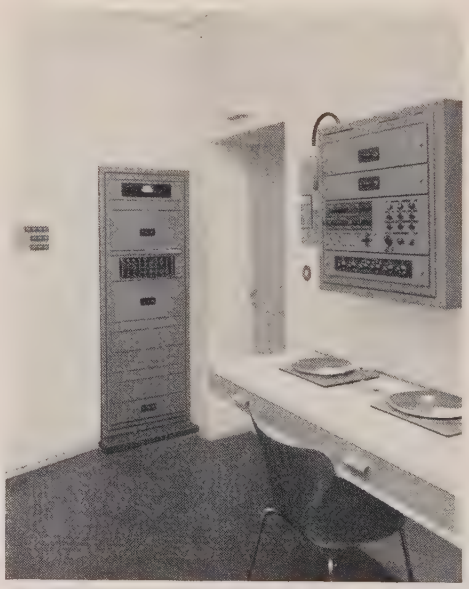


Fig. 4 Equipment of the projection booth: Record-player desk and amplifiers of the electroacoustic equipment (for the Small Hall), and main-amplifier rack of the sound-film equipment

Fig. 5 Roller-type projection screen in the Large Hall. Speaker's desk with built-in loudspeakers on the platform

both the projection stand and the projection booth. Substandard films and slides are demonstrated in the joined halls as well as in the Large Hall from the projection stand, in the Small Hall from the projection booth.

Since, as a rule, operators are not present during lectures, the public-address system remains permanently switched on. A switch is provided on either desk by means of which the lecturer himself can switch the microphones on and off, as desired. Each desk is equipped with two dynamic microphones, type MD 21. Moreover, two condenser microphones can be connected to plug sockets on the platform.

In the case of particularly important meetings, the sound volume can be controlled from the projection stand or – if the meeting takes place in the Small Hall – by means of an auditorium volume control installed in the last row of seats. A small home converser telephone system serves for establishing the necessary telephone connections between the lecturer, the operators at the projection stand and in the projection booth, and the hall porter (for enabling the latter to inform the lecturer in case of urgent calls).

A rather difficult problem was the restriction of the effective range of each induction loop within its allotted limits. In this case, too, a satisfactory solution was found by applying a special method for laying the loops. These induction loops can also be utilized for the wireless interpreting system which is intended to be installed at a later date. Having been imbedded in the concrete floor before the seats were set up, the loops were liable to be damaged by the subsequent construction work. Therefore, they were kept under continuous observation by means of a closed-circuit alarm system indicating an interruption of the loop by sounding a bell. In fact, this alarm was given several times when the loops were damaged by holes drilled into the floor. In each case, the trouble could be easily cleared.

As shown in Fig. 3, many combinations between the different loudspeaker and amplifier groups are possible. Therefore, in case individual units of the equipment should get out of commission, service can be maintained by a simple switching operation, special stand-by amplifiers being not required.

Experience has proved that all problems have been solved to the full satisfaction of all concerned, and that the performance of the electroacoustic and cinematographic equipments fully comes up to expectations.

The ideas and suggestions of the architect, Professor Hermkes, and of the acoustician, Professor Cremer, were realized by the House of Siemens, whose engineers were responsible for design and installation of the whole equipment. Excellent teamwork has contributed largely towards finding a most satisfactory solution.

Recommissioning of the Città di Roma Steam Power Station following the Floods in Central Italy

By Günter Treu

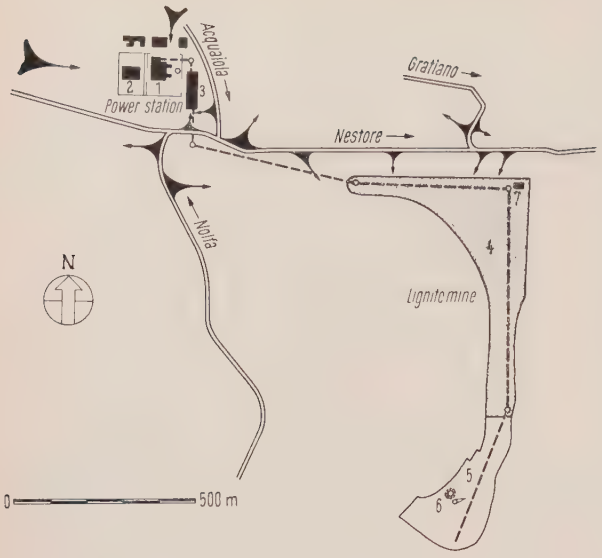
In the proximity of lignite deposits about 130 km north of Rome is situated the Città di Roma steam power station and its associated mine. The electrical energy generated in two power station units each with a capacity of 36 MW is supplied over a 150-kV double-circuit overhead line to Rome. The plant was constructed between 1956 and 1958 for the Società Mineraria del Trasimeno (SMT). A German consortium led by the Siemens-Schuckertwerke was entrusted with the planning, design and construction of the mechanical and electrical equipment both in the power station and in the lignite mine.

The lack of water at the site is so great that closed-circuit cooling using cooling towers is not possible and the installation of an air-condensing plant thus became necessary. The territory between the power station and the mine is crossed only by one small river, the Nestore, which has hardly any water the whole year round. With a view to any possible flooding, the elevation 0.00 metres of the power station was raised to 1 metre above the maximum known high-water level by banking up. The banks of the Nestore and of its tributaries in the vicinity of the plant were also dyked.

In the middle of September 1960 extremely heavy rainfall in Northern and Central Italy caused catastrophic flooding. Also in the region west of the power station all the rivers etc. overflowed their banks. As a result of this the water level of the Nestore rose with alarming rapidity in the early evening hours of September 18. Suddenly a tidal wave developed, probably due to the banking up of debris in the river bed to the east of the mine, and proved too much for the dykes of the Nestore and its tributaries. The water burst through the breaks in the dykes into the lignite mine. From the flooded regions to the north and west of the plant the water streamed through the basement window shafts and the exhaust steam pipes into the power station. Within a few minutes the basement with all the pipe and cable ducts was flooded and the water level had reached its maximum 20 cm above elevation 0.00 metres (see illustration on page 316).

At the time when the flooding took place, the power station was in operation with both turbines generating a total output of 40 MW. Since the flooding had taken place with astonishing rapidity, nothing could be done to prevent severe short circuits occurring in the metalclad 6-kV station-service switchgear at elevation 0.00 metres due to the inrushing water, and this of course led to the destruction of a few circuit breakers. The telephone and staff-location installations were also disrupted.

All the essential equipments – control room, d.c. plants, bearing-oil supply equipment for emergency operation of the machines and the electrical protective equipment of the power station – are installed above elevation 4.0 metres with the result that it was possible to take the power station out of service without mishap. No more than 15 minutes after the arrival of the tidal wave the entire power station had been brought to standstill.



Inrush of the floodwater into the power station and mine

The 60 metre long exhaust steam pipes (diameter 2.60 metres) of the turbines are run in a duct below elevation 0.00 metres to the air-condensing plant. In these pipes the inrushing water caused an uplift of about 300,000 kg. This led to bending of the piping whose anchoring was torn away in places. The uplift forces acted upon the turbines and their foundations and the danger of the machines coming into misalignment was very great.

During this time the mine filled with water. Part of the belt conveyor plant, its electrical equipment and the 6-kV switchgear installed in the mine were completely flooded over with up to 12 metres of water. The entire power station was in a terrible state and looked more like a mud-clogged building site.

In order not to endanger the power supply to Rome, the power station had to be brought back into service as soon as possible. After the floodwater had retreated, the power station authorities immediately set to work on the pumping out of the basement (approx. 10,000 cubic metres of water) with the aid of fire-brigade units. The Siemens-Schuckertwerke were informed of the situation by telephone and were requested to send specialists to the scene of the damage. In spite of severe staff shortages, it was possible with a minimum of delay to send turbine and switchgear specialists who had already been occupied earlier in the erection of the plant.

The first task was the restoration of the station-service power supply in order to be able to bring larger pumps, auxiliaries and the lighting into operation. In spite of the damage to the 6-kV station-service switchgear, it was possible on September 21 to energize the independent general service 6-kV switchgear from the 120-kV starting-up bus. The mine could therefore be pumped out (approx. 500,000 cubic metres of water), using the maximum possible number of pump units.

The high and low-voltage switchgear exposed after the water had been pumped out was immediately dismantled and cleaned and the components dried with hot air in improvised electric furnaces. These included a great deal of sensitive apparatus, such as relays, meters, measuring instruments, motors and 6-kV circuit breakers which had been under water for up to two weeks. Contrary to all expectations, the apparatus was once more found to be in good working order after re-assembly. Merely a few parts, which had not been cleaned and dried immediately after the water was pumped out due to the lack of time, had become useless through the effects of the oxygen in the atmosphere. The local power station personnel went about the task of repairing the damage in day and night shifts with exemplary zeal and skill.

An inspection of the first turbine gave no indication which might have led to concluding that a misalignment had taken place. The exhaust steam piping of the turbine was once more straightened out. Damage to the 6-kV station-service breakers could be cleared partly by installing spare parts. The breakers which had been destroyed were removed and replaced by the breakers still in working order in the second unit system. On October 10, three weeks after the catastrophe, the first generating unit could be started and operated at full capacity.

On inspection, the second turbine revealed no misalignment worth mentioning. However, in this case the aligning of the exhaust steam piping met with considerably more difficulty since a certain amount of distortion had taken place and this could only be eliminated by welding in a number of pipe sections.

In order to be able to bring the power station once more back to full capacity in as short a time as possible, manufacture was begun meanwhile on the new equipment, in particular the 6-kV circuit breakers, to replace that destroyed. In spite of a very full delivery programme, the Siemens-Schuckertwerke succeeded in supplying the equipment within an extremely short space of time. On October 26, a mere five weeks after the catastrophic floods, it was possible to bring the second turbine back into operation at full capacity.

Thanks to the exemplary cooperation of all concerned, the grave damage was repaired both economically and within a period much shorter than originally expected.

Pneumatic Tube Conveyor Systems Serve Large Mail Order Business

By Georg Tischer

The large German mail order firm of Neckermann KG in Frankfort uses pneumatic tube conveyor systems of the most modern design for handling interdepartmental bookkeeping. Up to 150,000 orders received daily from customers are distributed to the appropriate departments in a minimum of time. The company's new building, 1,970 ft in length and 660 ft wide, has been equipped with five different pneumatic tube conveyor systems: a full-automatic full-intercommunication system with automatic carrier control, a distribution system with automatic carrier control, two single-tube two-way systems, and a ticket distribution system. Since it was specified that two-way communication should be possible between some of the 40 stations, while other stations should be merely able to receive carriers from a single distribution point, the optimum solution was found to be that depicted in Fig. 1.

The tubes of the tube network, which has an overall length of over 2 miles, have an internal diameter of 3.93 in. and are made of seamless, drawn, hard lightmetal tubing with a wall thickness of 1.5 mm. The charging diameter of the carriers is 2.75 in., the charging length 13.77 in., the charging weight 35.3 ozs. The carriers are constructed of transparent material so that their contents can be identified from the outside (Fig. 2). In the systems with automatic carrier control, each carrier is provided with two index rings which may be set according to the chosen destination.

Full-automatic full-intercommunication pneumatic tube conveyor

In the full-automatic full-intercommunication pneumatic tube conveyor system, the carriers travel along dispatching channels from

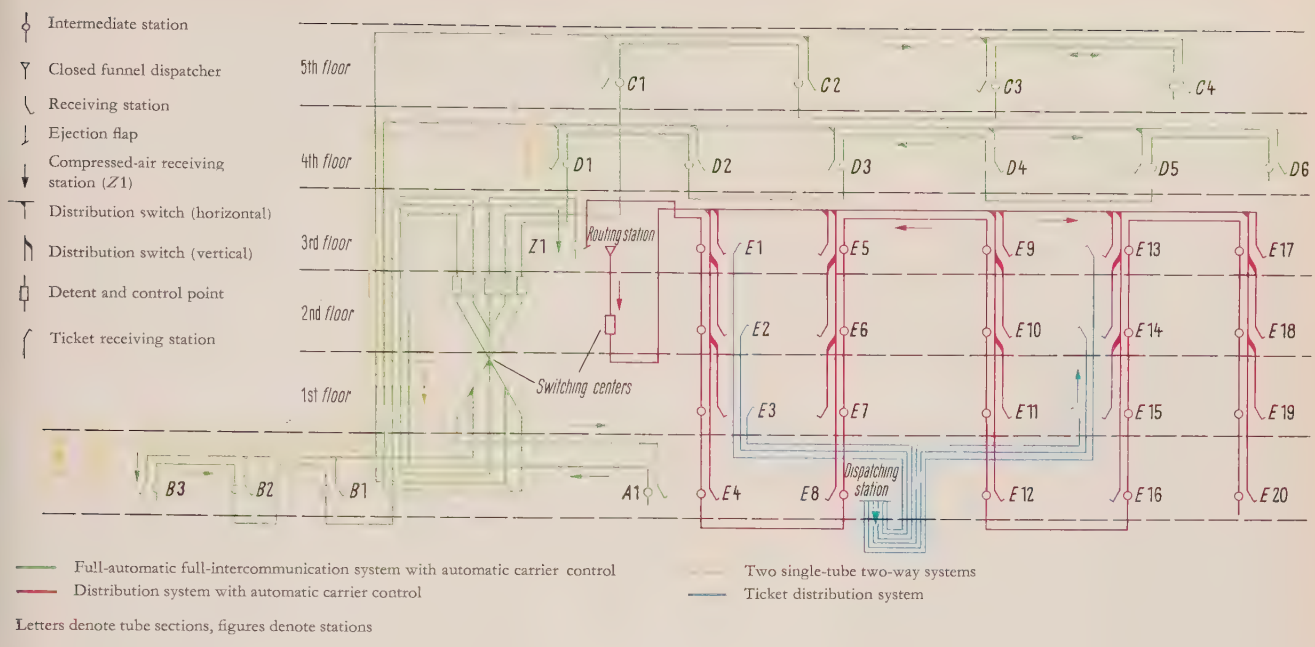


Fig. 1 Traffic plan of pneumatic tube conveyor systems in new building of the Neckermann KG

the stations (Fig. 3) to the switching center. The switching center (Fig. 4) is equipped with detent and control points, a relay assembly, a collecting funnel and a multi-channel switch. The detents hold back carriers that arrive simultaneously so that they can be scanned one at a time.

A contact above the detent and control point monitors the stacked height of detained carriers. Scanning fingers at each control point determine the destination of incoming carriers and communicate this information to the relay assembly, which controls all operations throughout the entire system. Collecting funnel and multi-channel switch are installed at junctions between dispatching and receiving tubes.

The switches in the receiving tubes are mounted horizontal or vertical according to requirements. Air-seals are provided in the form of pendulum flaps designed and arranged to secure smooth carrier travel; the transmission of carrier noise to the building structure is prevented by fixing the tubes with plastic clamps. As soon as a carrier reaches its destination, the tube it has passed through becomes immediately available for a new carrier.

The check point *Z*1 (see Fig. 1) rejects carriers that cannot be dispatched because their destination lies in a faulted receiving section, or because their index rings have been set to a station code that does not exist, or for some other reason.

Distribution system

Located next to the check point already described is the master station of the distribution system with automatic carrier control (see Fig. 1). In contrast to the full-automatic full-intercommunication system, the function of the distribution system is to dispatch prepared vouchers from a routing station to 20 storage depot stations. As the storage depot stations are not required to be able to intercommunicate either directly or with other stations, the two full-intercommunication systems are completely separate from each other. Thus the attendant at the routing station has to decide whether and when a carrier is to be transferred from one system to the other.

To improve operating reliability, the full-intercommunication systems are provided with facilities for monitoring air-locks and the travel time of carriers. If a carrier fails to arrive within the set time, or if the air current is interrupted, this condition will be indicated and further carriers automatically prevented from entering the respective tube.

Full-intercommunication systems can be equipped with various further facilities for rerouting carriers destined for temporarily unattended receiving stations to other predetermined stations, and for indicating the person for whom a carrier is intended when it arrives at a station serving several persons or departments.

Two-way systems and ticket distribution system

In the case of two-way systems, stations are interconnected in pairs by a single tube which is used in both directions. Each station serves for both dispatching and receiving.

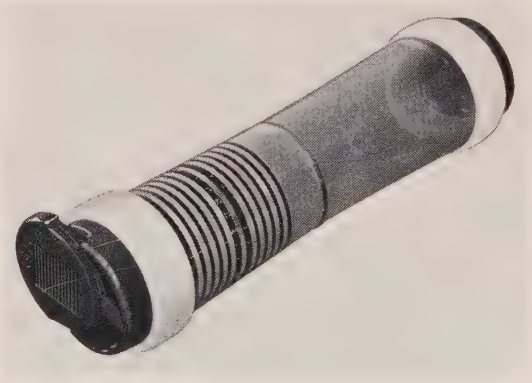


Fig. 2 Transparent carrier (internal diameter 100 mm) with index rings for setting destination

Fig. 3
Dispatching and receiving station of full-automatic full-intercommunication pneumatic tube conveyor system in storage depot

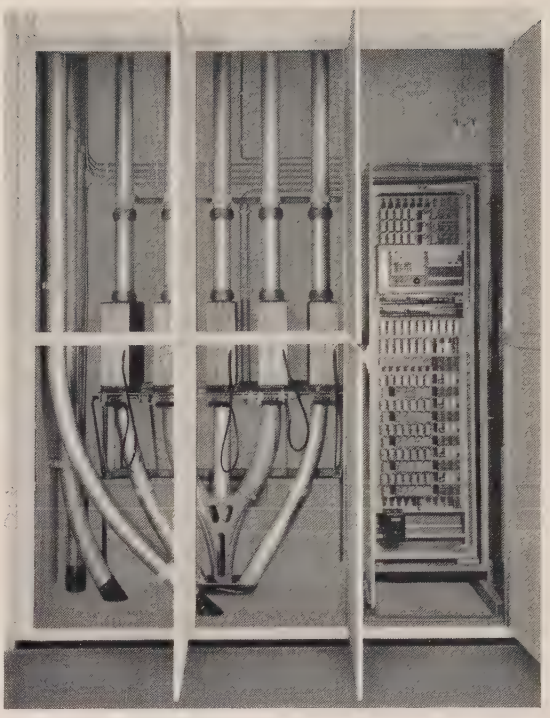


Fig. 4
Switching center and relay assembly of full-automatic full-intercommunication pneumatic tube conveyor system

Finally, a ticket distribution system conveys control slips from a dispatching station on the ground floor to six receiving stations located on different floors of the storage depot. Its flat-drawn brass tubes have an internal diameter of 70 mm × 10 mm. The slips are dispatched in a carton to which a diminutive sail is affixed. When the carton is inserted in the tube, the sail is caught by the current of air, thereby triggering a contact that switches on the arrival lamp and a buzzer at the receiving station.

Operating experience has shown that the pneumatic tube conveyor systems installed in the Neckermann building provide a satisfactory solution to the problem of interdepartmental bookkeeping. With their dispatching speed of 29.5 ft/sec, which is just under 19 mph, pneumatic tube conveyor systems are superior to all other short-haul transportation media.

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SIEMENS

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LEONHARD FUCHS

Control of Production Runs by PRODUKTOGRAPH Systems

4 pages, 5 figures, bibliography

Siemens Review XXVIII (1961) pp. 285 to 288

PRODUKTOGRAPH systems automatically record data required for controlling production. Data transmitters are operated by hand or automatically by the machine tools. Transmitters, central equipment and data processing are described.

SIEMENS

U.D.C. 621.039.572

GÜNTER HILDENBRAND

Siemens Training Reactor SUR

4 pages, 4 figures, 1 table

Siemens Review XXVIII (1961) pp. 289 to 292

The Siemens Training Reactor SUR is described as an example of the profitable use of small nuclear fission assemblies for training and instruction purposes. The reactor has a core of stacked fuel elements consisting of a solid-homogeneous mixture of uranium oxide (enrichment 20 per cent) and polyethylene moderator, a graphite reflector, shielding of lead and water jackets and suitable experimental arrangements. The neutron flux density is 5×10^6 n/cm²-sec. at a continuous output of 0.1 W.

SIEMENS

U.D.C. 621.395.5

KURT BARTHEL AND WERNER ZITZMANN

Line Equipment of 12-Mc Carrier System

8½ pages, 14 figures, bibliography

Siemens Review XXVIII (1961) pp. 293 to 301

The paper treats of the requirements that have to be met by line amplifiers as the result of CCITT recommendations, and of the noise powers to be anticipated with the Siemens system. Reference is made to the intermodulation products occurring when telephone and television signals are transmitted simultaneously. An account is given of ALC and the interoperation of the equipment at repeater stations with full or partial ALC. Remote powering and remote supervision are briefly described.

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WERNER LEONHARD AND SIEGFRIED WALLER

Programmed Digital Control for Test Stands in the Motor-car Industry

3 pages, 2 figures

Siemens Review XXVIII (1961) pp. 308 to 311

Programming facilitates endurance tests in the test station. A description is given of a digital programme control unit operating on the SIMATIC principle in conjunction with a dynamometer. The unit makes possible exact reproducibility of results by means of a stepped programme with punched tapes and a realistic simulation of road tests by using a magnetic tape.

SIEMENS

U.D.C. 534.86:778.55:727.3(43-2.2)

JOACHIM JÄCKEL AND WERNER LEMKE

Electroacoustic and Cinematographic Equipments of the Auditorium Maximum of the Hamburg University

3 pages, 5 figures

Siemens Review XXVIII (1961) pp. 312 to 315

The spaciousness and architecture of the new Auditorium Maximum of the Hamburg University (1,800 seats) required the design and installation of extensive electroacoustic and cinematographic equipments which are described in this paper.

SIEMENS

U.D.C. 621.313.1:621.317.66.082.13

RUDOLF FUSSAN

Innovations in the Determination of Efficiency by Retardation Tests

4 pages, 3 figures

Siemens Review XXVIII (1961) pp. 301 to 305

To make it possible to prove the guaranteed efficiencies of large generators within fine limits it is essential that the accuracy of the method of measurement employed in power stations be increased. The difficulties which arise in the input and retardation test method can be avoided by converting this method into a simplified retardation procedure with the aid of an electronic measuring instrument. This obviates the involved measurement of losses by wattmeters. In conclusion a study is made of a few general standpoints concerning measuring techniques used with the retardation method.

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PAUL GONSCHIOR AND FRANZ SCHWUB

Traffic and Quality-of-Service Observation in Dial Offices

3 pages, 4 figures

Siemens Review XXVIII (1961) pp. 305 to 308

Traffic and quality-of-service observations furnish information on the grade of economic efficiency and quality of switching equipment and networks. They are useful for reference in determining the type and size of investments to be made, furnish accurate data for planning new dial offices, and give an indication of the amount of maintenance required in any given case. The measuring equipment developed by Siemens & Halske for the measurement of traffic, destination factor and flow of traffic, and quality of service are described.

SIEMENS

U.D.C. 621.316.545:621.315.616.96

ERWIN HARTMANN

Indoor Isolators to New Standards (Insulation Ratings 10 to 30 kV) with Cast-resin Insulation

1 page, 1 figure

Siemens Review XXVIII (1961) pp. 311 and 312

Recent IEC recommendations and DIN Standards for high-voltage circuit breakers made it necessary to bring in line the specifications applying to isolators. The current and impulse-current ratings of the isolators are in accordance with DIN 43635 and now correspond to those of the circuit breakers. The Siemens-Schuckertwerke have already adapted their isolators to the new Standards. They have also changed over to the use of cast-resin insulation with its well-known advantages. The re-designed isolators comply with VDE 0111/2.61, insulation ratings 10 kV to 30 kV.

SIEMENS

U.D.C. 621.311.22(45)

GÜNTER TREU

Recommissioning of the Città di Roma Steam Power Station following the Floods in Central Italy

1 page, 1 figure

Siemens Review XXVIII (1961) pp. 315 and 316

During the extensive floods in northern and central Italy in September 1960 the Città di Roma steam power station and also the associated lignite coal mines were seriously affected. This placed the power supply of Rome in grave danger. Within a relatively short time, however, the damage in the power station was repaired and the two generating units put back into operation.

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SIEMENS

U.D.C. 621.54.002.71:655.5

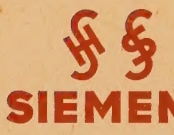
GEORG TISCHER

Pneumatic Tube Conveyor Systems Serve Large Mail Order Business

2 pages, 4 figures, bibliography

Siemens Review XXVIII (1961) pp. 316 to 318

In processing more than 150,000 orders received from customers daily, great value is attached to the rapid and reliable handling of interdepartmental bookkeeping. The new building of the Neckermann KG in Frankfort is equipped with five different pneumatic tube conveyor systems with 40 stations and a tube network 2 miles in length. The layout and operation of the various systems are described.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